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ON THE ACTUAL MAGNITUDE OF THE STAR ARCTURUS.

By E. W. Maunder, F.R.A.S. (*Assistant Superintending the Spectroscopic Department at Greenwich Observatory*).

As science has advanced, little by little the idea of stability, once ascribed to many objects, has ceased to be attached to any. The "everlasting hills"

> Are shadows, and they flow
> From form to form, and nothing stands;
> They melt like mist, the solid lands,
> Like clouds they shape themselves and go.

The great earth is but a planet, a wanderer; and the position of central fixity, which it was once supposed to hold, has been assigned to the Sun, only for the latter to show itself as thoroughly a wanderer as any of its dependent worlds. The idea of immovability, so long associated with the very name of the "fixed stars," has found no abiding refuge, even in the farthest heavens. The stars, too, are travelling, whence and whither as yet remain unsolved problems.

Yet "instability" is not the correct word to apply to all this ceaseless movement. We have learned to see in ordered motion a guarantee for the permanence of the solar system, and we not unnaturally infer that the same condition prevails in the greater world of the stellar universe. But motion need not by any means be of that character which tends to preserve the general state of affairs; it may be, on the contrary, eminently destructive. And recently we have been obliged to recognise stellar motions which, so far as we can at present see, are rather of this latter order than the former.

The first person to discover that any of the stars had movements of their own was Halley, who found that both Arcturus and Sirius were by no means "fixed" stars relatively to the stars which seemed to be their neighbours. In the case of Arcturus the movement was sufficiently rapid for an alteration of position to be detected, even without telescopic aid, within the lifetime of a single observer, if he were but endowed with the skill and care in observation shown by Tycho Brahe; whilst to long-continued observations it should have been very conspicuous. In fact, the star crosses a portion of the sky equal to the mean diameter of the full moon in about 900 years. Sirius was also found to be moving with about half the speed of Arcturus. Since Halley's day a few stars have been observed whose proper motions are even larger than that of Arcturus, in one case more than three times as large; but the vast majority of the stars do not show an alteration of their places anything like so great in amount. It follows, therefore, that observations must be carried on for a considerable time before we can determine in the case of most stars whether they are stationary or are in perceptible motion; and a still longer time must elapse before we can estimate with any degree of accuracy the speed and direction of their motion.

The most important source of our knowledge of proper motions, therefore, must be sought in observations made long ago, provided always that those observations were sufficiently accurate to bear comparison with observations made to-day. And here lies a difficulty, for astronomical instruments have been continually improved, and, what is yet more important, our knowledge of the errors to which they are liable, and of the methods which must be employed to correct for those errors, has continually advanced. So that when we wish to use early observations to compare with recent ones, it becomes a serious question as to whether we may not, by going too far back, lose in accuracy what we gain in time.

Fortunately, we have a number of stellar observations, made now nearly a century and a half ago, which are sufficiently accurate to be used for our purpose. These are the determinations of star-places made by the Astronomer Royal, Dr. Bradley, at Greenwich Observatory in the middle of last century, and which constitute our most important source for the determination of proper motions. From his observations, and from Lacaille's labours at about the same time in the southern hemisphere, supplemented by an ever-increasing number of more recent observations, we now know with reasonable precision the motions of between four and five thousand stars. And of these some seventeen or eighteen are moving more quickly even than Arcturus, and about fifty more quickly than Sirius.

The first and most obvious explanation of this more rapid apparent motion is that such stars are nearer to us; for it is clear that if two stars are moving with the same absolute speed in a direction at right angles to the line of sight, and one is but half the distance from us that the other is, the nearer star will seem to be travelling twice as fast as the more distant star—that is, its apparent angular motion will be twice as great. This is so obvious that when stars are being selected for observation for parallax, those are usually chosen first which have the largest proper motion; and in a fair number of cases the selection has been justified by the result.

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But not always. The star with apparently the swiftest pace of all, No. 1830 in Groombridge's catalogue, is so far removed that, when viewed from it, the entire distance of the earth from the sun dwindles down to less than a tenth of a second of arc, or about the dimensions of a halfpenny as seen from a distance of thirty-five miles! But if we are to accept the latest determination of the parallax of Arcturus, that star is five times more distant from us than even 1830 Groombridge. Light which takes but eight minutes to leap the gulf which separates the earth from the sun, will need nearly 200 years to reach us from Arcturus.

The latest value for the parallax of Arcturus, that of Dr. Elkin, is only 0·018″. Translated into more popular language, that means that the 93 millions of miles separating the earth from the sun, when viewed from Arcturus, appears no greater than an object an inch long (say a halfpenny, which is about an inch in diameter) would seem if placed on the cross of St. Paul's, and looked at from a balloon above Scarborough. But whilst the parallax of Arcturus is thus practically insensible, its annual motion is, as we have seen, very noticeable, for it amounts to 2·3″, or 128 times its parallax. Arcturus, therefore, traverses in a year 128 times 93,000,000 miles, or, in other words, its speed amounts to about 380 miles per second; it must traverse a distance equal to *twice* that which separates London from Liverpool in every second of time.

It will, of course, be quite clear that where the parallax is so extremely minute, we must not place too literal a reliance on the exact figure given for it. If, for example, we had to determine the distance of Scarborough from London, by measuring the apparent diameter of a halfpenny in the air above St. Paul's as seen from Scarborough, it is most abundantly clear that we should not be able to guarantee the distance to the nearest mile. One observer might put it at 100 miles and another at 300, and the difference would imply no slur on their skill. So it may well happen that the distance of Arcturus, and therefore its rate of motion, is, say, only half or a quarter that given above; but, on the other hand, it is quite as likely that both may be twice as large. Just as in the case supposed we could decide pretty positively that London was a long way from Scarborough, certainly *more* than 50 miles, so with Arcturus we feel tolerably confident that it has not any very sensible parallax; it must be distant from us at least 50 light-years.

Adopting, however, Dr. Elkin's figures, with this clear understanding of the limitation to be placed upon them, we are confronted with a further, and yet more amazing fact. Arcturus, though so distant, is one of the brightest of all stars; so bright, indeed, that whilst it is 11½ million times as far from us as the sun, the sun would look no brighter to us than Arcturus if removed to only 140,000 times its present distance. In other words, supposing the two bodies emit the same amount of light, surface for surface, the diameter of Arcturus must be 82 times that of the sun, or more than 70 millions of miles. Some estimations of the light of Arcturus, indeed, would give us a higher value still, and on the above assumption would oblige us to suppose that our earth and the sun, whilst still preserving their present distance apart, might both be embraced within its giant bulk, so that on this view Arcturus would exceed the sun in size as many times as the latter exceeds the earth.

Of course it is not likely that the surface of our sun is intrinsically so bright as that of a body which, however we put the case, so vastly transcends it in size. But it is to be borne in mind that the two bodies have spectra belonging to the same order, and on this account might be supposed not to differ extravagantly as to surface temperature. So that though "the imagination staggers at it," we can scarcely refuse to believe that our sun, enormous as it is, could claim any higher proportion, as compared with Arcturus, than at the best can Jupiter as compared with it.*

So far as our present information goes, Arcturus ranks as the swiftest, the brightest, and the largest of all the stars we know. What power is it that hurls it along at such a furious rate, a speed as nearly as may be the same as the utmost which our sun can occasion in a body falling from infinite space, and that only just as it reaches its surface?

That the general system of the stellar universe exercises an attractive power upon the individual stars may be assumed, but such attraction fails to account for speed such as this. Otherwise we should have many such winged fugitives. We have certainly no reason to think that Arcturus is the star closest to the very focus of sidereal attraction. Swift as it is, it is not much swifter than another "runaway," μ Cassiopeiæ, which has a speed of over 300 miles a second, and which lies in quite a different quarter of the sky, whilst a third, ζ Toucani, with a speed of more than 100 miles, is about as far from either as it can well be. Besides, Professor Newcomb has given it as his opinion that upon the most liberal assumptions as to the numbers and masses of the stars, 25 miles a second would be the highest speed which a body could attain if it fell from an infinite distance and through such a stellar system as he had supposed. The idea of the late Dr. Croll, that the original constituent bodies of the universe were endowed *ab initio* with high velocities, may fairly be said to be supported by the case of Arcturus.

Whilst, therefore, there are many reasons for believing that the stars we behold form but a single system, for we have no reason to suppose that we catch sight in any little misty nook or corner of some "external galaxy," these runaway stars, and Arcturus in particular, would appear to be visitors to, and not citizens of, our universe. For, so far as yet appears, they are travelling through our stellar system in straight lines, and with a speed so great that the united power of all the stars could not have acted as an effective attraction to give such a motion, and

* It will be remembered by those who read the article on Parallax in the February number of last year that the grouping together of the various determinations of stellar parallax seemed to show that there is no satisfactory concurrence between the determinations of parallax by various observers except in the case of stars with a parallax greater than one-third of a second. There have been seven determinations of the parallax of Arcturus made during this century, ranging, as will be seen from Mr. Sadler's list of parallax observations, from above one second of arc, to Dr. Elkin's small determination quoted by Mr. Maunder. Putting Brinkley's observations on one side, as no doubt unsatisfactory, we may probably feel confident that the parallax of Arcturus is less than a third of a second of arc, which would give a distance of at least ten light-years, and a diameter for Arcturus, on Mr. Maunder's assumption with regard to its intrinsic brightness, equal to about five times the diameter of the sun. If the densities of the sun and Arcturus may be assumed to be similar, Arcturus would have a mass equal to 125 times the mass of the sun —an aggregation of matter which is quite sufficient to stagger the imagination when it is conceived of as moving like a projectile through space with a velocity which is certainly more than double the velocity of the earth in its orbit.

If Arcturus and the sun are composed of similar materials, and the photosphere is, as suggested in the last number, the region corresponding to the highest temperature which precipitated particles can endure before being driven into the gaseous state, we should expect a similar amount of light to be given by equal areas of the photosphere in all gaseous stars composed of similar materials, and in stars of the same spectral type we should expect to find a somewhat similar absorption of the light in the region above the photosphere.—A. C. Ranyard.

cannot in the future act as an efficient drag to stop or reverse that motion.

"From the great deep to the great deep he goes" seems to be the sum of our information.

But we cannot help asking the question, idle though it may be at present, "What effect will the transit of so vast a body occasion in the stellar universe?" If we take its diameter, as above, at 82 times that of the sun, and its mass in proportion, we should find the latter as 550,000 times that of the sun. We need not adopt these very figures; we may content ourselves with saying that it must be a far more powerfully attracting body than our own sun.

How, if such a body passed through or near a star cluster, or a nebulous region, would it produce no effect upon it? There are certain oft-remarked peculiarities, shown alike in the Milky Way, the general distribution of the stars, and the shapes of certain nebulæ, which one could almost ascribe to the consequences of such a passage. I refer to the occurrence of dark holes, and of long streamers—tunnels and walls, so to speak. Is it impossible that some of these holes may mark the regions swept bare by some giant runaway, whilst the lines and streamers may testify to the disturbances caused in localities which it did not approach sufficiently nearly to denude?

RUDIMENTARY STRUCTURES.

By R. LYDEKKER, B.A.Cantab.

IF we turn to the word "rudiment" in any English dictionary we shall find it defined somewhat after the following manner, viz. "a first principle or element; the original of any thing in its first form; that which is first to be learned." While we shall also find the words "rudimental" or "rudimentary" explained as "initial; pertaining to rudiments."

Now we may presume that it was in this sense of the word "rudiment" that the terms "rudimentary structures" or "rudimentary organs" were originally applied to certain animal structures or organs, which, while appearing to be of no use to their owners, seemed to foreshadow structures fully developed and of functional importance in other creatures. At the time when these terms were first applied (it need scarcely be observed) the doctrine of special creations was almost universally accepted; but even then it is extremely difficult to see how there could be any philosophical defence for this use of the terms, since, if the structures so named were really primitive rudiments, their existence almost *ipso facto* implied some sort of genetic connection between the creatures in which they are found and those in which the kindred structures were functional.

With the advent of the doctrine of evolution, and the more careful investigations into the structure of animals which had by that time taken place, a total change of view as to the real nature and import of these so-called rudimental structures at once ensued. Thus it was soon found (not by conjecture, but from actual circumstantial evidence) that, in place of being the beginnings of structures which eventually became functional, these rudiments were really the remnants of structures which had once been functional but had now become useless. This change of view necessitates, therefore, that the term "rudiment" in zoology must be used in precisely the opposite sense to the one in which it is employed in ordinary parlance.

In order to make this application of the term quite clear, we may mention one or two illustrations taken from our own dress. For instance, at a time when people wore elastic-sided boots more frequently than they do now, the fronts of the boots were often ornamented with a set of "dummy" laces and lace-holes. These "dummy" laces being quite useless were, therefore, essentially rudimentary structures, which had been, so to speak, retained as an ornament. Again, the small black patch at the top of a judge's wig is the last remnant of his black cap or hat, and is, therefore, a useless rudimentary structure. Another case is afforded by the little pocket-like fold at the end of a university hood, which really represents the peak of the monk's cowl. Many other similar cases will occur to the reader, but the above are sufficient for our present purpose.

Some of the best instances in nature of rudimentary structures are to be found in the feet of the Hoofed or Ungulate Mammals, or that great group which includes Horses, Rhinoceroses, Cattle, Deer, Elephants, &c. In the Elephant and many of the earlier extinct members of this group each foot (as we have already mentioned in the article on "Teeth and their Variations") was furnished with five complete toes, each of which was supported by a separate bone, connecting it with the wrist in the fore limb, and with the ankle in the hind limb. These five connecting bones in the fore limb (to which we will confine our attention) correspond with those forming the upper part of our own hand, and, as following the wrist or *carpus*, are termed the *metacarpal* bones, or *metacarpus*. With the exception of the elephant the number of the fingers and metacarpals in all living Ungulates is, however, always less than five, the first finger, or that corresponding with our thumb, having invariably disappeared. In the Even-Toed Ungulates, such as Pigs, Deer, and Cattle, where the middle pair of fingers or hoofs (corresponding to our third and fourth fingers, the thumb being reckoned as the first) are always symmetrical to one another, we find as we advance to the more specialized species a gradual diminution in the relative size of the second and fifth metacarpals, as compared with the middle pair. Thus in certain extinct Pig-like Animals the whole of the four metacarpals were large, and completely separate from each other; while all the four toes were fully applied to the ground in walking. In the Pigs, however, the outer (2nd and 5th) metacarpals have become much reduced in size; while their small toes, as we may see any day for ourselves, only touch the ground when the animal is walking on soft or marshy ground. A still further diminution in the size of these lateral metacarpals is presented by the foot of the extinct creature shown in Fig. 1, where we find that they are only represented by small splints of bone (2 and 5) occurring at the upper and lower ends of the two middle metacarpals. In this animal these middle metacarpals (3 and 4) still remain separate from one another, but in the Deer, Sheep, and Cattle they have become completely welded together to form a single bone, known as the "cannon-bone." In some Deer the outer metacarpals are represented merely by splints at the upper end of this cannon-bone, and in others by similar splints at its lower end. In the

FIG. 1.—THE BONES OF THE UPPER PART OF THE FOOT, OR METACARPUS, OF AN EXTINCT EVEN-TOED UNGULATE (*Geloeus*).

Sheep and Oxen the upper splints have totally disappeared, while in the Giraffe both upper and lower splints are wanting, so that the metacarpus is represented only by the cannon-bone, composed of the originally separate 3rd and 4th metacarpals. With this more or less complete loss of the outer metacarpals, the hoofs of the corresponding digits have likewise gradually diminished in size, till we find them represented in cattle merely by the small and totally useless so-called "spurious hoofs," while in the Giraffe they have totally disappeared.

These "spurious hoofs" and the metacarpal splints are therefore rudimentary structures, of no possible use to their owners, but of the greatest possible interest to the naturalist, as telling in the clearest and most unmistakable language (if but the lesson be read aright) the story of the gradual evolution of the specialised two-toed foot of the modern even-toed Ungulate from that of a four-toed ancestor. That this history cannot be read the other way forwards, so as to regard the "spurious hoofs" and the metacarpal splints as the beginnings of functional toes, is obvious from the circumstance that it is only among the later formations that we meet with two-toed Ungulates; the majority of the early ones being four-toed. One other point worthy of notice is that one of the most specialised representatives of this group—the Giraffe—has succeeded in totally getting rid of these superfluous rudimentary organs, both externally and internally.

Precisely an analogous series of changes has taken place among the Odd-Toed Ungulates (Rhinoceroses, Tapirs, and Horses), in which the third, or middle, toe and metacarpal are always symmetrical in themselves. Thus the earliest extinct members of this group were furnished with five complete toes; in the Tapir the first toe (thumb) has disappeared, and the fifth is rather small; while in the Rhinoceros the disappearance of the fifth leaves only three functional toes, of which the middle one (third) is much the largest. Passing over some intermediate forms, we find in the extinct horse-like animal known as the Hipparion, the lateral toes have become very small, short, and useless, while their metacarpals are reduced to slender bones lying along the sides of the large third metacarpal. Finally, the modern horse has totally lost the lateral toes, and their metacarpals (2nd and 4th) are merely represented by small splints lying parallel to the upper end of the third metacarpal—now known as the cannon-bone—in the same position as the upper splints (2nd and 5th) in Fig. 1. Here then, again, we have true rudimentary organs—the remnants of bones once functional—which are not only of no sort of use to their owner, but, on the contrary, are absolutely injurious to him, since it is from inflammation, due to hard work, arising in these bones which gives rise to the disease known as "splint" in horses.

Except for the presence of these "splints" the horse appears to our ideas to be an absolutely perfect type of animal; and, indeed, so far as we can see, is the supreme development of which the Odd-Toed Ungulate stock is susceptible. If the horse were unknown, and the rhinoceros and tapir the only representatives of the Odd-toed group, it might have been readily conceived that their speed and agility could be improved by diminishing the number of their toes, and lengthening their limbs, but no one can suggest any improvement in the general structure of the horse, which is in every way adapted for the attainment of the highest speed, coupled with endurance and power.

Of perhaps still greater interest are the rudiments of hind limbs found deeply imbedded in the bodies of purely aquatic mammals, such as Whales and Dugongs, in which, as is well known, there is not the slightest external trace of such limbs, although the fore limbs are large, and modified into powerful paddles. The woodcut, Fig. 2, shows these structures as found in the Greenland Whale. The long horizontal bone represents the pelvis of ordinary mammals; while the nearly vertical bone (*f*), which is about eight inches long, appears to correspond to the

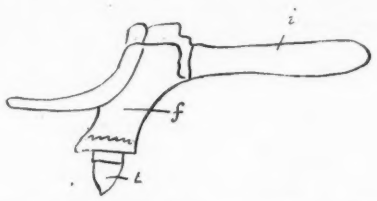

Fig. 2.—Side View of the Bones of the Rudimentary Hind Limb of the Whale. *i*, pelvis; *f*, thigh-bone; *t*, leg-bone.

thigh-bone, and the little nodule *t* is the sole remnant of the bones of the lower leg. In the Sperm Whale even these useless remnants of a hind limb have completely vanished, although parts of the pelvis still remain. Many considerations have led to the conclusion that Whales have originated from land mammals, and become gradually adapted to a completely aquatic condition; and the existence of these traces of a hind limb is, therefore, of especial importance from this point of view.

Much the same story is told by the Dugongs and Manatees, all the living species of which have lost every trace of a hind limb; although in a fossil Miocene species known as the Halithere, there was a pelvis, and a small but well-formed thigh-bone, clearly showing relationship with a four-limbed creature. The so-called coracoid process of the shoulder-blade of ordinary mammals is another excellent instance of a rudimentary structure. As we have already mentioned in the article on Egg-laying Mammals, this small process, which in the young animal ossifies from a distinct centre, is the sole remnant of the large coracoid bone found in the shoulder-girdle of birds and reptiles.

Teeth likewise furnish many very interesting cases of rudimentary development. It has, indeed, been stated that rudiments of teeth occur in very young Parrots, but this does not appear to be really the case; no trace of these organs being found in any existing birds. Since, however, the birds of the Secondary epoch had useful teeth, we may expect some day to find their rudiments in some of the Tertiary birds. One of the most remarkable instances of rudimental teeth occurs in the Greenland Whale, in which minute teeth are developed beneath the plates of "whalebone" or "baleen," with which the upper jaws are covered, although they never cut the gum. Again, the Narwhale, of the Arctic Seas, has one enormously long tusk—usually the left one—projecting from its head; while that of the opposite side is quite rudimentary, and remains as a little nodule in the gum, resembling the kernel of a nut in its shell. Among the Hoofed mammals, modern horses usually have but six grinding-teeth in the upper jaw; but occasionally a small seventh tooth, known as the "wolf-tooth," comes up in front of all the others. This small useless tooth, which falls out at an early period, represents a much larger and useful tooth found in the earlier members of the group to which the horse belongs. Many other mammals possess rudimentary teeth; thus bears have three little knob-like teeth between the upper tusk and the flesh-tooth, which are of no sort of use, and are soon lost. They correspond, however, to the well-developed anterior cheek-teeth found in the dog and

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the civet. Many bats, again, show one or more exceedingly minute, almost microscopic teeth, wedged in between the larger ones, and clearly pointing to their relationship with other bats in which these small teeth were large and functional.

Mention must not be omitted of the so-called "vermiform appendage" of that peculiar little pouch found at the junction of the large and small intestine in the human subject, and known as the *cæcum-coli*. Not only is this little appendage absolutely useless, but its presence may even be the cause of death, since there is at least one instance known where death has ensued from a cherry-stone having become firmly fixed in it. This appendage of the cœcum, as the "cœcum-coli" is called in comparative anatomy, is, however, the rudiment of an organ attaining an enormous size in some of the lower mammals, such as the horse and rhinoceros, in which it serves as a kind of supplemental stomach to aid in the absorption of the large quantity of food consumed by these animals.

Equally noteworthy is the little point of cartilage found in the outer rim of the ear of many persons, and shown at *a*, in Fig. 3. This little point, the existence of which was first brought to notice by Darwin, seems undoubtedly to be the last remnant of the extreme tip of the pointed ears of the lower animals. This existence appears to be very inconstant, even in members of the same family. Thus in one family known to the writer it is present in the father, but absent in three out of four of his children.

Fig. 3.—The Human Ear.

Perhaps, however, the most interesting instance of a rudimental organ in the whole animal kingdom is the central eye, of which mention has been made in the article on "Primeval Salamanders," published in the preceding number of Knowledge, found buried deep down in the brain of the lizard-like Tuatara of New Zealand. Here we actually have a perfect eye, fitted with cornea, lens, and pigment all complete, but totally concealed from all access of light. That this central eye is the remnant of one that was originally functional does not admit of doubt; but whether we have to go back to invertebrates before this was the case is, as mentioned in the article referred to, still a matter of uncertainty.

Among birds we may notice many instances of the wings having become rudimentary owing to the disuse of the power of flight. This occurs to a greater or lesser extent throughout the whole of that great group comprising the Ostrich, the Cassowary, the Kiwi, and the extinct Moas of New Zealand: all the bones of the wing having completely disappeared in the last-named birds. There are also numerous instances of the abortion of the wings in that larger group which includes all other birds; well-known cases being those of the Dodo of Mauritius, the Solitaire of Rodriquez, the Great Blue Water-hen (*Notornis*) of New Zealand, and the Great Auk; all of which, with the possible exception of *Notornis*, have become extinct from their incapacity to fly.

Insects, again, present us with many instances of rudimentary organs. Thus in the extensive group of Flies (Diptera) the hinder pair of wings, which are found fully developed in the Dragon-Flies (Neuroptera), have become aborted into organs like minute drumsticks, projecting from either side of the body, and known as "halteres," or balancers. In the Beetles (Coleoptera), on the other hand, it is the front wings which have been modified—not, indeed, so as to be absolutely useless, but so as to serve the purpose of covers to protect the delicate second pair which are carefully folded beneath them. In the same class the female glow-worm has, however, completely lost her wings, although they are retained in a closely allied Italian species. The fleas have both pairs of wings represented merely by very small scales, which are thus typical rudimentary organs.

We might go on indefinitely multiplying instances, but those we have cited are sufficient to show that rudimental structures must be regarded as the useless relics or remnants of structures or organs that were originally functional and useful; their occurrence only in the later and more specialized representatives of individual groups at once traversing any contention that might be raised as to their being the commencements of organs which were subsequently to become functional.

In thus gradually tracing an organ or bone first to its decadence, and then to its final rudimentary condition or complete disappearance, we have before us one of the most weighty pieces of evidence in support of the doctrine of evolution that can be adduced. No hypothesis, indeed, but that of evolution can possibly offer any rational explanation of rudimentary structures; whereas this doctrine assigns a satisfactory and definite reason for their existence. On the old view of the separate creation of every species, the existence of the useless, and to some extent harmful, splint-bones in the horse's foot is absolutely inexplicable in any way that will commend itself to a thoughtful and unbiassed mind. The following instance will, perhaps, serve to illustrate this point more fully. All of us are aware that paddle-wheel steam-vessels were in use long before those propelled by a screw were invented. Now if a naval architect had to alter a paddle-steamer into one driven by a screw, we should not be surprised to detect in the altered vessel traces of the foundations of the paddle-boxes, or part of the axle that once turned the paddle-wheels. If, however, this architect were ordered to construct a screw-steamer new from keel to deck, and actually went out of his way to build the foundations of paddle-boxes, and the ends of the axle for paddle-wheels, which were not only ugly and absolutely useless, but also an actual impediment to the free use and working of the ship, no one would have a moment's hesitation in declaring that such a man was utterly unfit for his business.

THE SILVER-FISH INSECT.

By E. A. Butler.

THIS curious little creature has had a varying reputation, at one time being regarded as harmless, and at others accused of causing serious damage. There is abundant evidence to show that the latter is the true view, and we are therefore justified in including the Silver Fish in the list of our domestic pests. Scientifically it is known as *Lepisma saccharina*, and its popular names, which are numerous, such as Silver Witch, Sugar Fish, Wood Fish, Sugar Louse, Bristle-tail, and Silver Fish, refer to different details of its structure or habits. It is an elongate, flattened-conical or fish-shaped wingless creature (Fig. 1), with six legs, two long antennæ, and three long bristle-like organs by way of tail; the whole being of a bluish or greyish silvery lustre, tinged with yellowish colour about antennæ and legs. The silvery appearance is due to vast

numbers of minute scales with which the body is covered, and which are well known to microscopists as test-objects, closely allied to the celebrated *Podura* scales. The insect is about one third of an inch long, and is not unfrequently found in houses, though apparently less commonly now than formerly.

The earliest notice of this little creature is to be found in a curious book, entitled *Micrographia*, published by R. Hooke in 1665, at the instance of the Royal Society, to detail some of the first observations made in this country by means of the microscope. In this book, which represents a good deal of careful work, the insect is called the "Small silver-colour'd Book-worm," and, after the manner of the times, an enormously magnified figure is given, executed with great care, and sufficiently accurate to be easily recognisable. Hooke's notice of the insect is introduced as follows:—"As among greater Animals, there are many that are scaled, both for ornament and defence, so are there not wanting some such also among the lesser bodies of Insects, whereof this little creature gives us an Instance. It is a small white Silver-shining Worm or Moth, which I found much conversant among Books and Papers, and is suppos'd to be that which corrodes and eats holes through the leaves and covers; it appears to the naked eye a small glittering Pearl-colour'd Moth, which, upon the removing of Books and Papers in the Summer, is often observ'd very nimbly to scud, and pack away to some lurking cranney, where it may the better protect itself from any appearing dangers. Its head appears bigg and blunt, and its body tapers from it towards the tail smaller and smaller, being shap'd almost like a Carret." In connection with this extract it is to be remarked that the words "moth" and "worm" were at that time used with a less restricted signification than at the present day; the former did not necessarily imply the existence of wings in the animal so denominated, nor the latter the absence of legs. It was a time when the classification of natural objects was in a most imperfect condition, and no very definite conception was attached to many of the terms employed. "Moth" and "worm" were interchangeable words implying any small invertebrate creature, especially if of destructive proclivities.

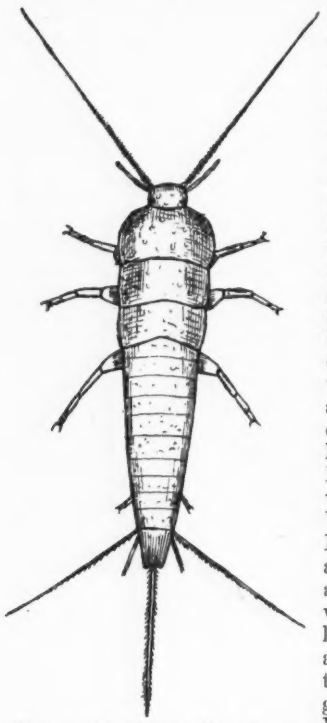

Fig. 1.—The Silver-Fish Insect (*Lepisma saccharina*).

To proceed to a more detailed examination. The insect consists of a head, three segments constituting the thorax, and eleven composing the body. The rounded head, as already mentioned, carries two long, slender antennæ, composed of a multitude of minute joints, and pointing forwards. They are generally more or less imperfect, from damages received in consequence of the delicacy of their structure. When complete, they are about two-thirds the length of the body. There are also two little black heaps of eyes, one at each side. The usual mouth parts are present, and there are two pairs of palpi—the maxillary, five-jointed, and the labial, four-jointed (Fig. 2). The mandibles, or biting jaws (Fig. 3), are long and narrow, and toothed at the free end with several hard prominences. All three thoracic segments are of large size, being, in fact, both the widest and longest segments in the whole insect. The prothorax is the largest of the three, in marked contrast to the last pest we considered—the book-louse—where it was the smallest. Each of these three segments, as usual, carries a pair of legs, consisting of the customary parts, and each terminated by a pair of claws. No wings are ever developed, nor are any traces of such organs ever perceptible. The abdomen consists of a series of segments tapering gradually towards the tail, the last one carrying three long bristle-shaped appendages. The skin is of a delicate texture, and is covered with multitudes of minute iridescent scales of exquisite structure (Fig. 4), closely resembling those of butterflies, and readily detached by a touch. These are the cause of the silvery appearance, and produce a very slippery surface, which, combined with its extraordinary agility, makes the Silver Fish a difficult creature to catch and hold.

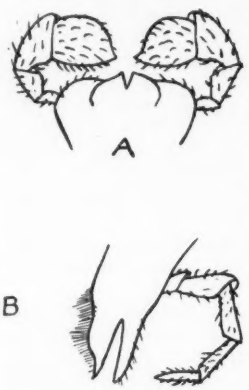

Fig. 2.
A. Labium and Palpi of Lepisma.
B. Maxilla and Palpus of Ditto. (*After Lubbock.*)

Fig. 3.—Mandible of Lepisma. (*After Lubbock.*)

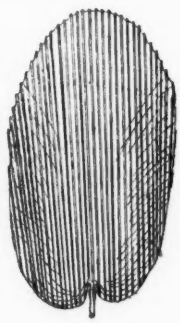

Fig. 4. Scale of Lepisma.

Like other animals belonging to the Arthropodous (jointed-legged) division of the animal kingdom, the Silver Fish sheds its skin periodically, thereby providing for an increase in size; but apart from the slight changes produced by this regular renewal, its appearance is not altered throughout life. When hatched from the egg it has six fully-developed legs, as when mature, and is similar in form, differing only in the proportions of the parts and in depth of colour. As there is no quiescent stage corresponding to the pupa of other insects, and no acquisition of wings, the Silver Fish may be truly said to undergo no metamorphosis. And the same remark applies to all the members of the group to which it belongs; none of them ever possess wings or exhibit that succession of changes of form to which the name "metamorphosis" is applied. We have here, then, quite a different case from that of the bed-bug

or book-louse. These were apterous members of groups which are normally winged in the adult stage. The Silver Fish, on the other hand, belongs to an order which is normally apterous throughout life. This order is called Thysanura, and, as restricted by Sir John Lubbock (*i.e.* without the Collembola, or Springtails, small jumping insects found in profusion under stones, logs of wood, &c.), contains only a very few British insects. Three only are likely to have been generally noticed; viz., the present one; a similarly shaped but considerably larger brown one, found amongst heaps of stones near the coast; and a minute pale yellowish-white creature with two long tails, which may be found under stones that have lain long on soft damp ground. A special interest attaches to this last (*Campodea staphylinus*), seeing that, in the words of Sir John Lubbock, "there are good grounds for considering that the various types of insects are descended from ancestors more or less resembling the genus *Campodea*. . . . If these views are correct, the genus *Campodea* must be regarded as a form of remarkable interest, since it is the living representative of a primæval type, from which not only the Collembola and Thysanura, but the other great orders of insects have derived their origin." Some naturalists regard the Thysanura as allied to the Neuroptera—the group to which we referred the book-louse—and speak of them as degraded Neuroptera, including them amongst that section of the order called Pseudoneuroptera.

Little need be said as to the digestive system, since it is constructed on the usual insect type. The alimentary canal is a straight tube running through the body. The gullet enlarges into a crop, which is succeeded by a grinding apparatus, in the form of a globular gizzard furnished with six tooth-like projections; after this comes the true or digestive stomach, succeeded again by the intestine, at first narrow, but in its hinder part broader; the Malpighian tubules are four in number. When contemplating the functions of the Silver Fish in Nature, Hooke, the author of the *Micrographia*, falls into the following curious reflections, very characteristic of the physiological ideas of the times in which he lived: "When I consider what a heap of Sawdust or chips this little creature (which is one of the teeth of Time) conveys into its intrals, I cannot chuse but remember and admire the excellent contrivance of Nature in placing in Animals such a fire, as is continually nourished and supply'd by the materials convey'd into the stomach, and fomented by the bellows of the lungs; and in so contriving the most admirable fabrick of Animals as to make the very spending and wasting of that fire to be instrumental to the procuring and collecting more materials to augment and cherish itself, which indeed seems to be the principal end of all the contrivances observable in bruit Animals." The nervous system is of the usual type, consisting of a pair of ganglia above the gullet, in the head, and a chain of eleven pairs down the body, beneath the digestive apparatus. The little creature breathes by means of tracheæ, like other insects, and some of these may be seen through the skin during life, or immediately after death, especially those running down the legs.

Lepisma saccharina is essentially a vegetable feeder, and the substance most in accord with its taste is apparently starch. This preference makes it sometimes a by no means insignificant foe; for starchy substances are so largely used in connection with books and papers, that *Lepisma* may do serious damage in libraries and museums if not carefully guarded against. Several instances of this are on record, and doubtless many more might be collected if the foe were more generally known and more easily detected in the act of marauding; but as it is a lover of darkness and concealment, and easily takes alarm, rapidly slipping away in a weird, ghost-like manner when interrupted, it is frequently difficult to obtain anything more than circumstantial evidence of its depredations. In 1879 Professor Westwood exhibited to the Naturalists Association a print, the plain border of which had been eaten in holes by *Lepisma*, while the parts covered by the printing-ink had been left untouched. In India, Government records have been similarly damaged; for this insect is very generally distributed, and reports of the injuries it has caused come in from all parts of the world. The paste used in bookbinding or in papering walls forms a prime attraction to these starch-loving creatures, and its age is a matter of little importance; the oldest and driest seems as attractive as the newest and freshest. Hence they do damage to the bindings of books and to paper-hangings, often eating holes in the paper, either for its own sake or for the sake of the paste behind. The present writer had an unpleasant experience in this direction; a large case of transparencies, made of different thicknesses of paper pasted together, had been laid aside for some years, when, on being opened, a colony of *Lepisma*, that had evidently discovered and been revelling on the store, hurriedly scuttled away into remote and dark corners. On inspection, it was found that while comparatively little damage had been done to the paper itself, only the thinner parts having been nibbled, yet in many places the paste that united different thicknesses had completely disappeared, the papers in consequence falling apart and hanging in tatters. Muslin curtains, again, have been attacked in consequence of the starchy stiffening in them, and eaten in holes. Similarly, starched collars, cuffs, and other articles of clothing have been damaged. Silk garments and silken tapestry have also suffered, the material in this case being destroyed, apparently not so much for itself as for the stiffening it contained. In 1882, Gustav de Rossi complained that *Lepisma* had eaten holes in a carpet, in the dust-covers of chairs, and other furniture, in the paper lining of an insect store-box, and lastly in the wings of such specimens as it could reach in a rather carelessly preserved collection of butterflies. Some of these last instances evidently indicate that the Silver Fish, though very partial to vegetable matter, is quite prepared to seek its food in the animal kingdom should the opportunity be afforded.

Some of the most curious and annoying of the damages wrought by this insect have taken place in museums, where the inscriptions on the labels of specimens have been rendered illegible by their little jaws, though the labels themselves have been left intact. One such instance is recorded by Dr. Hagen from the geological museum at Boston, U.S.A. A new form of label, printed on good card, had been employed for re-labelling the collection. The specimens being kept in little square boxes, the ticket was folded in half, one portion being placed under the stone, whereby it was kept in place, while the name of the specimen and its locality were written on the upturned half. The whole collection having been thus neatly labelled, in the course of the next twelvemonth the surfaces of the cards gradually changed in appearance, looking as if they had been scraped, many of the inscriptions being in consequence completely destroyed, and others partially obliterated. The change being a gradual one, and no foe of course being visible, as the work of destruction was done at night, it was at first a puzzle what could be the cause. After a while, however, the culprit was discovered in the shape of a certain species of *Lepisma*, not quite the same as our *L. saccharina*. The insects had evidently been attracted by the superior finish of the

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labels, the glaze on which, composed of starch, had proved so strong a temptation to them, that every exposed part was scraped, the only portion left untouched being that on which the specimen was actually resting, which was of course inaccessible. Labels of ordinary common writing-paper had not been attacked. The damage done was a serious one, as the whole collection had to be re-labelled; and in such cases the loss sustained may be far more serious than the mere cost of a set of cards, since, the use of the specimens depending to a great extent upon the details of locality, &c., if these be obliterated and not recoverable, their value is much diminished. Another instance is from the Museum of the Jardin des Plantes, Paris. Here some white labels had been printed with a red border, the colour of which was due to red lead. The white parts of the labels were eaten away, but all the red parts were left untouched, the pattern being sometimes neatly picked out. A third instance occurred in a museum in New South Wales, where some hundreds of labels were, after only fifteen months, rendered useless. It is evident that loose papers are much more obnoxious to the attacks of the Silver Fish than those that are closely packed, there not being room in the latter case for so large an insect to creep between the leaves; hence an obvious and useful precaution would be to keep all separate papers, where possible, tightly packed together.

The case of books is particularly unfortunate; for the wood-boring beetle, *Anobium*, which makes furniture worm-eaten, will also attack the covers and leaves of books, boring holes in them; but it does not like starch, hence it has been proposed to use paste made of that substance as pure as possible in binding books. But it now appears that by so doing they will be made, though distasteful to *Anobium*, only all the more acceptable to *Lepisma*. It does not appear to be always so easy to keep out this foe of books as one might have imagined; even an iron safe has been found insufficient to protect the treasures enclosed therein, for in the year 1885 Mr. R. Adkin exhibited at a meeting of the Entomological Society a *Lepisma* of some kind which was found swarming on some account-books that were constantly kept in an iron safe in Aldgate, London. Visions of the possible erasures which might thus be effected in important legal documents are not reassuring, and show *Lepisma* to be an enemy to which no quarter must be given. Perhaps one of the strangest spots in which the Silver Fish has been found is old martins' nests, where on one occasion M. Cornelius discovered more than forty examples in the middle of winter.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE TEMPERATURE OF THE CORONA.

To the Editor of Knowledge.

Dear Sir, ... I have been reading your article on the Photosphere with great interest. But may not a rapid increase of temperature as you proceed downwards in the corona upset the law of increase of density which must exist in a solar atmosphere composed of gases which obey or approximately obey Boyle's law? I notice that in your article on the height of the lunar atmosphere, in the *English Mechanic*, you state that the depth at which the pressure of an atmosphere must double is dependent on the temperature, and yet in dealing with the sun, the hottest of all bodies, you preface your remarks by saying "neglecting differences of temperature," and proceed to apply a law which would apply at the temperature of the earth's atmosphere. . . . . A. G. Taylor.

[I dismissed the question of the change due to a difference of temperature too summarily. But the argument I used is not practically affected by assuming that the temperature of the coronal matter is a hundred times hotter than it probably is. The polarization of the light of the corona down to the sun's limb, and the fact that the solar absorption lines have been observed in the continuous spectrum of the coronal light, points to the conclusion that the sun's light is dispersed by matter other than gaseous matter in the coronal region, and that there are minute particles, either solid or liquid, down to the level of the photosphere. In other words, that the temperature does not probably much exceed 2457° Cent. I take this temperature as a convenient one for calculation.

If the earth's atmosphere were raised to a uniform temperature of 2457° Cent., the height of the lower half of the atmosphere would (if its height at 0° Cent. is about $3\frac{1}{2}$ miles) be raised to about 35 miles, for the volume of a gas varies as $\frac{T}{273}$ where T is the absolute temperature in degrees Centigrade. At a height of about 70 miles, if the temperature were uniform as we proceeded upwards, the density would be reduced to a quarter of the density at the earth's surface; for the lower half of the upper half of an atmosphere composed of a gas which approximately obeys Boyle's law will occupy the same thickness as the lower half of the atmosphere; for it is only compressed by the weight of the uppermost quarter of the atmosphere, and every stratum of it is under half the pressure of a corresponding stratum in the lower half of the atmosphere. Consequently, the density of such an atmosphere would go on halving with every increase of altitude of about 35 miles. This reasoning neglects the decrease of the earth's gravity and the increase of superficial area of the spherical shells in ascending; corrections which would affect the result in contrary directions and would make no practical difference if applied.

If this heated atmosphere of the earth were taken to the region of the photosphere where solar gravity is $27\frac{3}{4}$ times as great as terrestrial gravity, the strata which here occupied a thickness of 35 miles would be reduced to a thickness of about a mile and a quarter, for the weight of the gas above every such stratum would be multiplied by $27\frac{3}{4}$, and its volume, according to Boyle's law, would be correspondingly decreased. Consequently the density of such a solar atmosphere would be decreased to about a millionth on passing upwards through a height of about 125 miles. It is obvious that the height of the atmosphere round the sun, or any planet, will not be affected by the amount of gas. For if we double the amount of the atmosphere we double the weight of the compressing layers, and the height of the lower half atmosphere is not altered, double the quantity of gas being under double the pressure.

If the temperature of the coronal region were 27027° Cent. (an altogether improbable supposition), the density of a coronal atmosphere would be decreased to a millionth part on passing upwards through a height of about 1,250 miles, instead of 125 miles as in the former case. But since some of the coronal structures extend to a height of over a million miles above the photosphere, and very many of them to a height of half a million miles, it is evident that the coronal structures cannot be floating in a coronal atmosphere.

A minute particle in the corona would be retarded in its fall under the action of solar gravity—by the backward kicks* of molecules evaporated from its under surface towards the heated centre—and the retardation would be greatest in the region where the evaporation proceeds most rapidly. We should expect to find such falling particles checked in their downward course most rapidly before they were finally evaporated, for two reasons. 1. Because the weight of the falling particle would have already been greatly sweated away; and the total weight of the particle would bear a smaller proportion to the weight of the molecules evaporated towards the heated centre in a unit of time; and (2) Because we should expect the force and number of the backward kicks to increase very rapidly when the particle enters a region where the heat is such that it will rapidly be completely evaporated.

We should expect the falling particles to accumulate at a level when their falling motion was thus rapidly checked; and this region of accumulation of highly incandescent particles I take to be the brilliantly incandescent region we call the photosphere.

The Kinetic theory of gases gives us some clue as to the rate of increase of temperature in an atmosphere. Neglecting the changes of temperature due to the radiation of liquid and solid particles, the temperature of a gas varies with the square of the mean velocity of its molecules; and the mean velocity must vary, as the projectile velocity which would carry a molecule up to the limit of the atmosphere. The transformation of a part of the energy of translation into internal energy of the molecules will not affect this relation, for there is evidently a constant relation between the internal energy of a molecule and its energy of translation.—A. C. RANYARD.]

* Molecules evaporated from the surface of such highly-heated small bodies would have a velocity relative to the falling small body of several thousand feet per second. The falling particle must in consequence suffer a recoil in a direction away from the source of heat, which would tend, at first slowly and ultimately rapidly, to diminish the velocity of its fall. The mean velocity of hydrogen molecules at a temperature T is $1{\cdot}06\sqrt{\frac{T}{273}}$ miles per second. Consequently, at a temperature of 2184° Cent. (9×273° C. absolute temperature), hydrogen molecules would have a mean velocity of 3·18 miles per second; and the velocity of such molecules evaporated from a surface heated to 2184° must be much greater than the mean velocity of the molecules of the heated surface, for the swiftest molecules will be the first to free themselves from the attracting molecules of the heated surface. Hence evaporation cools an evaporating surface, for it lowers the average velocity of the molecules left behind.

STELLAR EVOLUTION.

To the Editor of KNOWLEDGE.

SIR,—By the death of Dr. Croll we have lost an accomplished student of the most subtle problems of Astronomy and Geology. Whatever may be thought of his later works, such as *Stellar Evolution*, it cannot be denied that they exhibit both learning and ambition. Dr. Croll attempts to open a door before which even Herbert Spencer pauses. Anxious to reconcile the comparatively short age physicists assign to the sun with the enormous age of the earth required by geology and biology, Dr. Croll assumes the existence of sidereal motions entirely independent of gravitation. He then discusses a theory of stellar collisions on a scale so tremendous, that two equal or nearly equal bodies, meeting together at any imaginable velocity, will engender, by their impact, heat and light in the two transfused bodies capable of lasting any millions of years. His reasons for the great age of the earth are elaborately and interestingly unfolded, but his impact theory for eking out the age of the sun admits of question. He does not notice that his theory tends, in the long run, to destroy the proper motion of the stars on which it depends. He says: "It will be only when the two bodies, coming from contrary directions, collide with equal momentum, that the entire motion will be stopped. In most cases the resulting stars will have more or less motion. 1830 Groombridge is moving at the rate of 200 miles per second. This 200 miles per second is simply a part of the untransformed motion of translation which the materials composing the star had at the beginning." In short, every imaginable collision, according to this impact theory of Croll's, either entirely destroys the proper motion of stars, converting it into heat, or, when the bodies colliding are unequal in mass and velocity, transforms part of their proper motion into heat, so that every impact of cold and dark or of bright bodies is followed by less proper motion of those bodies until, ultimately, all proper motion is lost.

Dumfriesshire. J. SHAW.

[I do not feel sure that two stars coming into collision from opposite directions would not behave as elastic bodies. It has already been suggested by Prof. George Darwin that two solid bodies, such as meteors, moving with planetary velocity in opposite directions, would probably rebound from one another like elastic bodies, by reason of the gases generated between the meteors when they came in contact, and it seems probable that two great gaseous bodies would equally rebound by reason of the great heat developed in the gas at the region of contact.

If they behaved approximately like the elastic molecules of a gas, and if the Universe is infinite, we should expect to find stars, like molecules, moving with every variety of velocity on either side of the mean velocity which, in a gas, corresponds to the temperature of the gas. It is evident that meteoric bodies and stars can only approximately behave like *perfectly* elastic bodies, for wherever heat is generated there must be a loss of some energy of translation. That is, it will be converted into molecular energy, and radiated into space.—A. C. RANYARD.]

MR. RIDER HAGGARD'S ASTRONOMY.

To the Editor of KNOWLEDGE.

SIR,—I have just been reading Mr. Rider Haggard's book, *King Solomon's Mines*, and perhaps your readers would care for some notes I have made on Mr. Haggard's astronomy.

Joshua made the sun and moon stand still; but this is nothing to what Mr. Haggard attempts. His travellers start across the desert; and we find, if we count up the days till a date (21 May) is given, that they must have started on the evening of the 14th or 15th of May. We have further confirmation of this in the author's mentioning that Captain Good (who had shaved until he started across the desert) had a ten days' growth of beard on the 25th (p. 110).†

We also find that the great dance and witch-hunt took place on the 3rd of June, for the travellers, who had been keeping careful count of the days, all agreed that the next day was the 4th of June (p. 172); the dance, therefore, took place either twenty or twenty-one days after their start across the desert. And yet Mr. Haggard tells us

† The references are all to the octavo edition (Cassell and Co.), twenty-fifth thousand, 1886.

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that when they started the moon was rising *at 9 p.m.* "in all her chastened glory" (p. 72); whereas, three weeks afterwards, we are told that the moon rose *at 10 p.m.* (p. 158).

But this is a very slight slip compared with the following. On the same night that the moon rose at ten, we are told it was the full moon: "About ten the full moon came up in splendour" (p. 158). It is a marvellous thing that the moon should be rising at 10 p.m. three weeks after it had risen at 9 p.m.; but it is still more marvellous that the full moon should rise at 10 p.m. in the centre of Africa in winter, when the sun must have set more than four hours before.

Another wonderful event had also taken place in the meantime, for the crescent moon rose *after sunset* one night and shone brightly for some hours. "The sun sank, and the world was wreathed in shadows. But not for long; for see, in the east there is a glow, then a bent edge of silver light, and at last the full bow of the crescent moon peeps above the plain and shoots its arrows far and wide, filling the earth with a faint refulgence" (p. 136).

No wonder that the travellers "stood and watched the lovely sight, while the stars grew pale before this chastened majesty." No wonder that one of them remarked that "there are a few things I am thankful to have lived for, and one of them is to have seen that moon rise over Kukuanaland" (p. 136).

Still greater marvels, however, have yet to follow; for on the very next day, the 4th of June, at about half-past one in the afternoon, there was a total eclipse of the sun! A total eclipse of the sun the day after full moon! It used to be supposed that eclipses of the sun could only take place at new moon, but, according to Mr. Haggard, "nous avons changé tout cela." Mr. Haggard apparently did not go so far as to intend that it should be new moon the day after the full; we presume so, at least, from the fact that he mentions that on the night of the 4th of June the moon was shining serenely most of the night (pp. 196 and 197), an event that would hardly be expected to occur at new moon—even a Haggardian new moon.

The eclipse of the sun, besides taking place at a time when no other eclipse of the sun has ever taken place, also "beats the record" in another way. The eclipse was total for an hour or more, as we see from these sentences:—"Before we reached the gate of the kraal the sun went out altogether. Holding each other by the hand, we stumbled on through the darkness" (p. 187). . . . "For an hour or more we journeyed on, till at length the eclipse began to pass, and that edge of the sun which had disappeared the first became again visible" (p. 188). Considering that Mr. Haggard might have beaten the record with a total eclipse of ten minutes, he might have been a little more moderate in his demands, and not have taken an hour. It is really almost enough to make us ask whether he can be telling the truth!

R. H. Kirby, Jun.

Haverthwaite Vicarage.

[There is such a passion for laborious accuracy now-a-days amongst critics. If the astronomy was right, no doubt there would be some fault to find with the botany or natural history of the story. Why should we not accept and enjoy astronomical impossibilities as we do the princes and wishing-stones of the novelists? An opportunity for criticism adds so much to the enjoyment of most people. It gives a sense of superiority which human nature keenly enjoys, especially at a moment when the work of the novelist or artist might otherwise make us feel our inferiority. The dress-maker, no doubt, keenly enjoys looking for the impossible dresses in the Academy pictures, and the engineer enjoys wondering at the folly of the impossible machines. I remember hearing of a French astronomer who went to see *Aida*, beautifully put on the stage in Paris. He had been told that there was a most wonderful night-scene, in which the constellations were rightly figured. The moon rose in the right place, and even the stars twinkled. It certainly added to his enjoyment of the scene, which was really very beautiful, to find that the stars did not scintillate properly; they twinkled and showed no more change of colour near to the horizon than they did at a considerable altitude. What it would have cost the management to set this right I do not know. He would not have enjoyed the piece any more, and nobody else would have noticed it.

Mr. Kirby might safely have put eight minutes for the longest possible duration of a total solar eclipse. If the moon's shadow passed centrally over the earth when the moon was at its nearest and the sun at its farthest, an observer at an equatorial station at the sea-level might enjoy a totality of 7m. 58s. He would need to be at a very lofty station to enjoy a totality of eight minutes.—A. C. Ranyard.]

RECURRING DECIMALS, &c.

To the Editor of Knowledge.

Dear Sir,—I am much obliged to Mr. Willis and Mr. Barrett for pointing out that $\frac{1}{n\,r-1}$ will not always give complementary periods.

The rule, however, given by Mr. Barrett in the beginning of his valuable paper follows at once from my investigation, p. 213, last line but one, if for S we write $\frac{1}{p}$, as well as a method of getting the first half of the period. Those who have written in Knowledge on recurring figures and the properties of numbers were not aware of any mystery in connection with the subject, but pointed out peculiarities, some of which at least would never have come to light from theory, but when noticed were easily explained. But this is not always so easy, as the following extract from Todhunter's *History of the Theory of Probabilities* will show:—"Fermat enunciated various remarkable propositions in the theory of numbers. Two of these are more important than the rest. One of them, after baffling the powers of Euler and Lagrange, finally yielded to Cauchy; and the other remains still unconquered."

R. Chartres.

DAY OF THE WEEK FOR ANY DATE.

To the Editor of Knowledge.

Dear Sir,—In one of your contemporaries last week I observed a paragraph professing to give a method of finding the day of the week of any date. On testing the method given, I found it both insufficient and erroneous. Thus, *e.g.* to find out the day of the week for January 1st, 1889, we have:—$(89+22+1+9)\div 7$, which gives a remainder 2, which indicates Monday; a wrong result. As a matter of fact, the figure 9 ought to be 3; and besides that, the method does not make provision for leap years, nor for years previous to the nineteenth century. By means of a little observation and experiment, I have stumbled across a method which appears to me at once simple and correct. I shall be glad, however, if any of your readers who take an interest in the subject will test it by any dates they are sure of; as dates for bygone years are not always available. The fundamental defect of the ordinary methods is, as it seems to me, the necessity of making corrections for each separate month;

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The Lick Observatory, California, from a Photograph taken by Mr. S. W. Burnham during the Month of February 1890.

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and these, after the freshness is worn off, are liable to be forgotten. My plan is this :—

I. To find the last day of May for any year of the present century.

Rule.—Take the last two figures, add a quarter, divide by 7, and the remainder indicates the day of the week. *E.g.* (15+3)÷7 gives rem. 4=Wednesday=31st May 1815. Therefore the Battle of Waterloo, on the 18th June 1815, was fought on a Sunday.

II. To find the last day of any odd month (except January) for any year of the present century, *i.e.* of March, May, July, September, November.

Rule.—Proceed as before, but in addition add 5 and take away the number of the month. *E.g.* 15th February 1876 fell on a Tuesday. Here (76+19+5−3)÷7=rem. 6=Friday=31st March. The figure 3 stands for the *third* month. Similarly, 5 would stand for May, 11 for November, &c. The number 5 which is *added* is invariable.

III. To find the 1st day of January is equivalent to finding the 1st day of October, which is readily obtained from the last day of September got by the previous rule. *E.g.* Find 1st January 1865. (65+16+5−9)÷7=0=Saturday=30th September. Thus the 1st January falls on Sunday.

This rule, however, is affected by leap years. In these years simply take the last day of September as it stands, and you have the 1st of January. At a future time I will enter on the question of "old style" dates.

I am,

Wavertree Park College, Yours faithfully,
Liverpool, Jan. 10. ROBT. W. D. CHRISTIE.

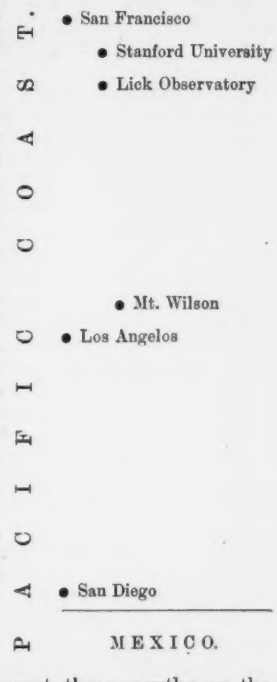
CALIFORNIAN OBSERVATORIES.

BY S. D. PROCTOR (widow of the late R. A. PROCTOR).

IT would have interested Mr. Buckle to note the Westward drift of civilisation as indicated by the foundation of large observatories near to the Pacific coast of America. California is likely to become a most important centre of astronomical observation; partly owing to the natural advantages offered by its mountains, which rise above the sea of clouds that drift in from the Pacific, and partly owing to the gift of the late Mr. James Lick, and other causes which seem to have stimulated astronomical enterprise. Such a number of large telescopes are being ordered for Californian observatories, that Messrs. Alvan Clark told me they were seriously thinking of moving their works to California; partly in order to be nearer to their work, and partly because the warm climate of California would enable them to work more expeditiously in winter. A great object-glass needs to be allowed time to cool after each touching and before each testing, and in the cold weather of the Eastern States this causes a serious loss of time. Messrs. Alvan Clark's works are now situated at Cambridgeport, near to Harvard Observatory, and not far from Boston. They have an order for an object-glass of 40 inches diameter, and are at present working on the crown-glass lens. It is for a telescope to be mounted by the University of Southern California, on one of the mountain-tops near to the town of Los Angelos—possibly on Mount Wilson.

Prof. Pickering is also thinking of establishing an observatory in the same region, which is to contain the great photographic telescope of 24 inches diameter given by Miss Bruce, of New York. It will be somewhat similar to the portrait lens combination used by Prof. Barnard when taking the beautiful photographs of the Milky Way published in the July number of KNOWLEDGE, but will give pictures on four times the scale of Prof. Barnard's photographs. The short focus of such a combination, as compared with an ordinary observing telescope, will enable fainter objects and larger outlying regions of nebulæ to register themselves on the sensitive plates than can be photographed with the telescopes which will be used for the international photographic survey of the heavens, or even with Mr. Isaac Roberts' reflector.

Another large instrument is about to be ordered by the Stanford University—to be placed between San Francisco and Mount Hamilton. The Messrs. Alvan Clark have already commenced work upon an 18-inch refractor for the Proctor Memorial Observatory, which will be situated near to San Diego, at the extreme southern limit of California, where it abuts upon Mexico. All these observatories will be within a short distance (10 to 40 miles) of the Pacific coast. The southernmost of them, the Proctor Memorial Observatory, will about correspond to the latitude of Jerusalem, while the Lick and Stanford Observatories near to San Francisco about correspond in latitude with Athens. They consequently all of them have an advantage over English observatories for the observation of equatorial and southern stars.



The site of the Lick Observatory was chosen in pursuance of a report made by Mr. Burnham in 1879. He spent three months on the top of Mount Hamilton in the autumn of that year, observing with a 6-inch refractor, during which time he discovered several new and difficult double stars, and was much impressed with the clearness and steadiness of the atmosphere as compared with that of other mountain stations from which he had observed.

The height of Mount Hamilton is only about 4,200 feet above the level of the sea, an altitude which does not raise the observatory above a sixth part of the atmosphere which covers the earth at the ocean level, though no doubt it enables the observers to escape the lower strata of our air which are most laden with dust and fog. Even in such a southern position as North California, where in the valleys fruits ripen as they do not in England, and flowers bloom even in the winter, observers living on such a mountain height have, in the winter months, a great deal to contend with.

During the winter of 1890, when the picture reproduced in the plate was taken by Mr. Burnham, twelve feet of snow fell on Mount Hamilton from the beginning of December to the end of February, and during many days no communication was possible with the outside world; a fierce *blizzard* was blowing, which could not be faced. The wind frequently blows at the rate of 60 miles an hour, and Prof. Holden states that no higher record has

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been obtained (except in one instance 70 miles), because when the wind gets up to 60 miles an hour the anemometer blows away. During the summer season, when I have visited Mount Hamilton, everything works easily. A coach arrives daily from San Josè, 26 miles away, and the telegraph and telephone lines work without hitch. But in the winter all is different. Prof. Holden says the snow gathers on the wires and freezes into ropes four or five inches thick. The force of the wind blows this heavy mass about, either breaking down the wires or tearing down the poles. The houses of the astronomers are almost uninhabitable, by reason of the cold. The only fuel they have is wood, which has to be brought up from where it grows, 1,200 to 1,400 feet below. They commence to collect fuel during the summer, and when there is a high wind no fire can be kept in an open fire-place. The flames are blown out into the room. Even with closed stoves the smoke is blown down through the fire, though every experiment has been tried with ventilating chimney-pots. Meat and all other provisions have to be brought up by the stage-coach, and when it cannot arrive the little colony on the mountain are as isolated as Arctic explorers.

All these difficulties greatly add to the expense and inconvenience of carrying on an observatory on a mountain-top. Mount Wilson, though farther south, is higher than Mount Hamilton, and the amount of snow and the inconveniences for winter residence will probably be as great there as at the Lick Observatory, though there is some talk of carrying a railway to the summit of Mount Wilson. The traffic would, however, be interfered with unless they bored a tunnel up through the last two thousand feet; and this would be difficult to maintain, as there are continual earthquakes along the whole Californian coast. The summit of Mount Hamilton is much shaken by such earthquakes, which frequently crack the masonry of the water reservoirs, causing leakages, which sometimes interfere with the hydraulic machinery for working the great telescope; without water-pressure the floor of the observatory cannot be raised and the dome cannot be turned.

The Proctor Memorial Observatory will be situated about a mile from the town of San Diego, at the extremity of a cable-line which leads out from the city. A very suitable piece of ground of about ten acres has already been given for its site, and sufficient money has been subscribed to warrant the ordering of an 18-inch object-glass. The observatory will be situated on the edge of the cañon of the San Diego River, about 500 feet above the sea-level and about ten miles from the Pacific Ocean. It is just high enough to be above the level of the sea of fog which rolls up the great cañon from the sea and shuts off the radiation from the heated valley below. The observatory will be essentially a teaching observatory and will be open to the public every evening from dark till ten.

In America there seems to be a wider and more general interest taken in astronomy than in England. This is evidenced by the great number of visitors to the Lick Observatory during the summer months. It is open to the public every Saturday night, and, in spite of the great distance from the nearest town (San Josè, 26 miles), strings of coaches frequently bring up as many as two and three hundred visitors. Astronomical lectures are also more largely attended in America than here, and popular books on astronomy are more generally read. The results of such a wide interest in astronomy are no doubt very far reaching, and probably have more to do with the methods of thought and real progress of a nation than the compulsory powers of school boards and competitive examinations.

PHOTOGRAPHY APPLIED TO THE STUDY OF ELECTRIC DISCHARGES.

MARKINGS have been frequently found upon the skin of persons killed or injured by lightning, which have been described by doctors as "ramified," or, by those who speak in Saxon-English, as like the branches or roots of a tree, or like the fronds of a fern radiating from a centre. The marks are usually a bright red, and they slowly fade away as the patient recovers. It has for some time been known that somewhat similar markings may be obtained by receiving the spark from a Ruhmkorff coil on photographic dry-plates, which may be afterwards developed and used as negatives for printing. Monsieur Trouvelot, of the Meudon Observatory, who has made many photographs of lightning-flashes—some of which were published in Knowledge last year—has further developed this research by packing dry-plates together face to face, with sheets of tinfoil between them, and taking the spark through the pile so built up. The pictures reproduced in the plate are from some beautiful silver prints made from such electrically-altered dry-plates, which have been given by Monsieur Trouvelot for reproduction in Knowledge.

In his account of them given to the French Academy, M. Trouvelot says:—

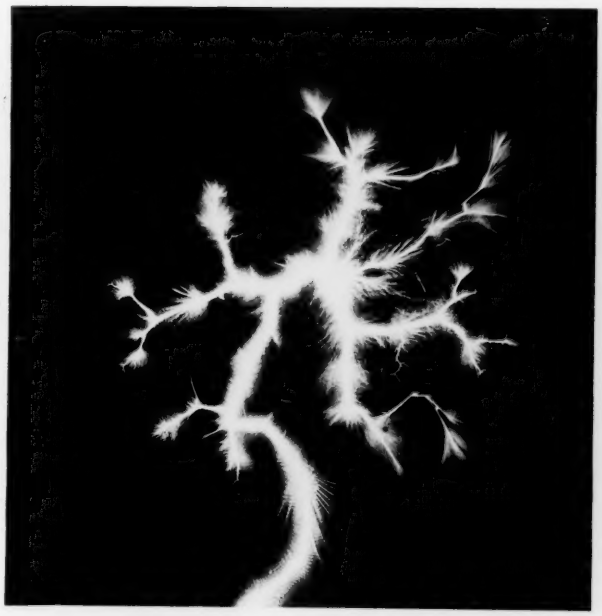
"En faisant ces expériences, je constatai que l'étincelle ne suivait pas toujours exactement la surface de la plaque sensible, et qu'elle s'en éloignait même souvent en faisant de nombreux soubresauts. Il me vint alors à l'esprit qu'il était possible, peut-être, de donner plus de stabilité à l'étincelle et de la contraindre à se tenir en contact immédiat avec la surface sensibilisée. Dans ce but, je préparai un simple condensateur à lame d'étain, à l'aide duquel j'obtenais, le jour suivant, des images de l'étincelle qui étaient d'une netteté remarquable et d'une élégance de forme tout à fait inattendue: les photographies jointes à cette Note en donneront une idée complète.

"Les images données par les pôles opposés diffèrent complètement, quant au caractère et à la forme. L'image donnée par le pôle positif est très sinueuse et très ramifiée; de ses branches principales partent des milliers de longues fibres dentelées, qui rappellent certaines algues. L'image produite par le pôle négatif diffère: ses branches principales sont, en général, formées de lignes droites qui, souvent brisées à angle droit sur ellesmêmes, leur donnent une certaine ressemblance avec la foudre placée entre la main du Jupiter des Grecs. . . . .

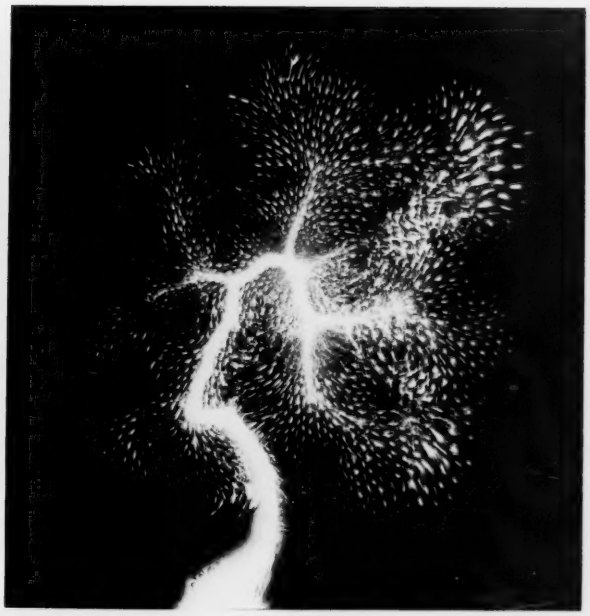
"Si l'on place face à face la couche sensible de deux plaques photographiques, on obtient des images induites opposées qui ont, les unes, le caractère négatif; les autres, le caractère positif. L'image positive induite, obtenue par une décharge négative directe, consiste en une petite tache ronde, d'aspect nébuleux, du centre de laquelle s'échappe une petite branche de ramille positive qui marche de la circonférence au centre. L'image négative induite, obtenue par une décharge négative directe, consiste en une minuscule fleur négative supportée sur sa tige, et dont la marche se fait du centre vers la circonférence...."

Notices of Books.

The System of the Stars. By Miss Agnes M. Clerke. (Longmans, Green & Co.) The great progress that has been made in stellar astronomy, especially during the last twenty years, has been admirably summarised in this remarkable book, which explains with great simplicity and



1. Trace left by Direct Discharge, Negative Pole.



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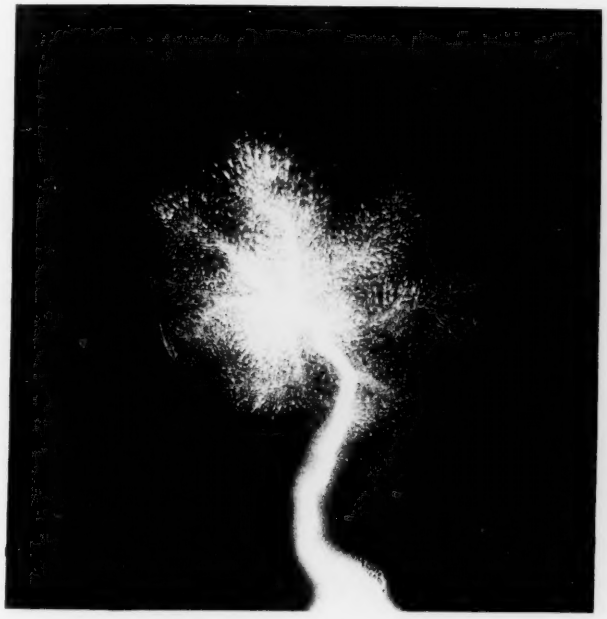
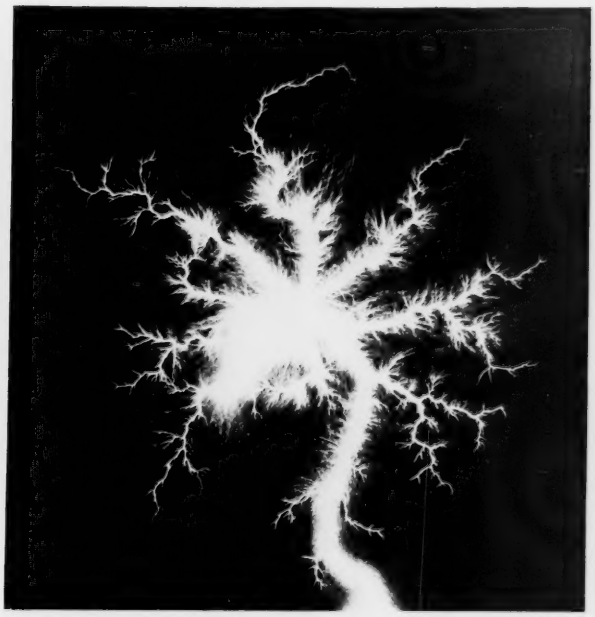


3. Trace left by Induced Discharge, Positive Pole.



4. Trace left by Direct Discharge, Positive Pole.

The above Pictures represent the Traces left upon Four Photographic Dry Plates by a Single Discharge from a Rhumkorff Coil, obtained by Monsieur E. L. Trouvelot, of Meudon Observatory.

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clearness a bewildering variety of theories, and marshals into orderly arrangement a vast harvest of facts gathered from a very wide field of reading. Miss Clerke is essentially an historian of astronomy, and she is most accurate and conscientious in the presentation of her facts. If any fault is to be found with her method, it is that she is too conscientious in presenting theories with which she evidently does not agree, and too sparing of criticism, so that observations and theories of a comparatively worthless character sometimes appear side by side, and are treated with almost equal respect as work of the highest class. The book is a perfect encyclopædia of information, and its references to original authorities, as well as its tables, are of the greatest value. Naturally, in dealing with so large a subject, there are some omissions; but probably few specialists will read the book who do not find more references to papers they did not know of, than omissions of those they would consider worthy of a place in its pages.

The chapter on variable stars of short period contains some interesting curves representing the variations of the intensity of the light of such stars. The authorities for some of the most interesting of these curves are not given. They seem to show a variation of the light of stars of the Algol type near to their minima which would not be accounted for by Prof. Pickering's theory that the eclipsing star moves in an elliptic orbit. No suggestion of another theory for the cause of such strange variations is given in the text. Mr. Peek's light curves of irregular short period variables are not referred to. Miss Clerke seems to adopt Sutton's theory of the construction of the Milky Way. She thinks that the bifurcation of the stream is "beyond question a physical reality," and that by "adopting the simple view that the Milky Way is very much what it *seems*, we shall get nearer to the truth than by indulging in more recondite speculations. The book will, we trust, interest many new readers in the great problems of stellar astronomy.

Annals of a Fishing Village. Edited by J. A. OWEN. (Blackwood and Sons.) From notes of his early life and boyish pursuits supplied by "A Son of the Marshes," the editor has compiled these "Annals" which give a picture of out-of-the-world North Kentish village-life, such as it was before the railway came to destroy its primitiveness and simplicity. The hero, a kind of juvenile Thomas Edward, is a boy who is never so happy as when watching the sea-birds which swarm upon the marshes that spread for many a mile round the village, or when otherwise studying nature at first-hand. Despite much opposition and many a beating for mud-bespattered garments, he persists in his explorations along shore till he becomes thoroughly versed in the manners and customs of the finny and feathery tribes that haunted those parts. Young people whose tastes run in the direction of natural history will find pleasant reading in the vivid pictures of bird-life here presented; while the quaint superstitions of the fisher-folk and the ingenious devices begotten of their contraband dealing appeal to the imagination and impart a pleasing air of mystery.

Fathers of Biology. By CHARLES MCRAE, M.A., F.L.S. (Percival and Co.) In this little book we have a sketch of the lives and work of five of the heroes of science, whose labours constitute some of the chief events in the history of biology for a period of about two thousand years. It is from the zoological side of biology exclusively that the instances are taken, the examples selected being Hippocrates, Aristotle, Galen, Vesalius, and Harvey. The author's special aim being to counteract a "tendency among students of anatomy and physiology to imagine that the facts with which they are now being made familiar have all been established by recent observation and experiment," the reader will of course not look for an exhaustive account of the labours of these great men. It is chiefly upon such parts of their work as were based on original research in the domains of physiology and comparative anatomy, and upon the discoveries and generalisations that resulted therefrom, that emphasis is laid. Bearing this limitation in mind, Mr. McRae has judiciously performed his task; and his book will be useful as an introduction to the history of anatomy and physiology.

Chambers's Encyclopædia. Vol. VI., Humb—Malt. The completion of this, in all respects, most admirable work, advances apace, and the present instalment, if less interesting in the range of its articles than its predecessors, maintains their reputation. A novel and excellent feature of this new edition is that which allows a man to speak for himself, as, *e.g.*, in the biographical notice of Professor Huxley, thus securing an indisputable record of facts. The article on "Jesus Christ" shows that Archdeacon Farrar can prune his rhetoric when space compels; that on "Jerusalem" is from the pen of Mr. Walter Besant, whose prominence as a novelist has eclipsed his worth as an archæologist. The articles throughout, markedly in the bibliographies appended to many of them, are up to date.—E. C.

Ferdinand Magellan. By F. H. H. GUILLEMARD, M.A., M.D. (World's Great Explorers Series). London: Geo. Philip & Son. 1890.—The author of the *Cruise of the Marchesa*, one of the most delightful books of modern travel, has essayed to tell the story of the voyages and discoveries of the first circumnavigator of the globe, Fernãs de Magahães, better known as Ferdinand Magellan, a Portuguese noble, born in 1480. The tale is one with which the readers of biographies of old explorers are familiar; a tale of service spurned by their native country and accepted by another nation; of dangers and difficulties before which those of our modern globe-trotters are trifling; of ships ill-equipped; of crews disaffected; of ever-contrary elements; but with victory at the end, and posthumous glories. So with Magellan: triumphant in discovery of the long-hoped-for Strait, and then death in his forty-second year in a miserable skirmish with savages. So far as the details of Magellan's early years are concerned, Dr. Guillemard has to make his bricks without straw, but for the main work of the explorer's life there is ample material for the author's capable pen. The text is enlivened with woodcuts, both quaint and modern, and by a series of beautifully clear maps illustrating the progress of discovery in the New World.

SOME PRACTICAL APPLICATIONS OF ELECTRICITY.

By J. J. STEWART, Cavendish Laboratory, Cambridge; *late Demonstrator of Physics at University College, London.*

IT may be interesting to consider in a simple way some of the scientific principles which underlie the great industrial development of electricity, and to explain, without entering into technical details, or using abstruse terms, the machinery and apparatus used for generating the electric light. With this object in view, I propose to describe first of all the dynamo-electric machines which are the chief instruments employed in producing the electric current, and then, perhaps, to go on to consider secondary batteries, arc and

glow lamps, and other important adjuncts in a complete electric light installation.

I.—Dynamo-electric Machines.

The first dynamo-electric machine ever constructed was that made by Faraday. This great physicist, the prince of experimenters as he has been called, discovered that when a disc or flat plate of copper was made to rotate between the poles of a powerful magnet, currents were produced in the plate from the centre outwards. By making a wire touch the revolving plate with one of its ends and bringing the other one in contact with the rim, he found that a current of electricity passed along the wire and could be made to indicate its existence by deflecting the needle of a galvanometer, decomposing a chemical solution, or by any of the well-known effects produced by electricity in motion. Faraday saw the importance of this discovery and the great uses in the way of practical application to which it might be put, but he did not himself stay to develop it; he left that to others, and with it the wealth which might thus be acquired, and himself went on to investigate other obscure and little known phenomena connected with physics and electricity, regarding this as his proper work, and exhibiting in his conduct the true scientific spirit. When many years afterwards he went to see the first application of this discovery of his to the production of the illumination of the North Foreland lighthouse, he said, after looking at the large magneto-electric machines there, "I gave it to you an infant; you have made it a giant."

Dynamo and magneto electric machines consist essentially of a coil of wire—"the armature," as it is called—rotating between the poles of a large magnet, the poles being bent round so as to approach each other and have the armature between them. This magnet may be either a permanent magnet of hard steel or an electro-magnet consisting of wire coiled round a soft iron core, a current of electricity being made to circle round the wire coil, and thus magnetising the iron core while it lasts. It is the latter arrangement which is almost universally used now, though the magneto machines with permanent magnets were the earliest form.

A magnet produces an influence in the neighbourhood around it, and this surrounding neighbourhood is known as the "field of force" of the magnet, *i.e.* the sphere in which its influence can be felt. A magnetic needle or bit of iron-filing placed in this field sets itself to point along the "lines of force" of the field, that is, the lines along which the magnetic force acts, and which form curves round the magnet, running out, as it were, from one pole, and curving round to the other. Anyone may see the form of these lines of force for himself by placing a bar-magnet underneath a sheet of paper, and then sprinkling iron-filings on the paper. On tapping this, the filings will set themselves along the lines of force in beautiful regular curves. Here the small fragments of iron are themselves made magnets while under the influence of the powerful magnet in whose "field" they are, and therefore place themselves lengthways along the lines of force, that is, along the line of action of the resultant magnetic force at the place where each one is.

When a coil of wire, or armature, is made to revolve rapidly in the strong field of force which occupies the space between the poles of a powerful electro-magnet, currents are produced in the coil. These currents alter their direction through the coil every time the latter changes its position with reference to the poles of the magnet. The side of the coil which was opposite the North pole is after half a revolution opposite the South pole, and the influence of the South pole tends to produce an opposite current to that of the North pole. Here we have an "alternate current" dynamo machine. As the coil, or armature, rotates with great speed—some hundreds of revolutions per minute—these currents, in alternating directions, succeed each other very rapidly, and if an electric arc-lamp is placed on the circuit, it will be lit up. In this case, it is not necessary that the current be sent round the circuit in one direction only; but although the terminals of the lamp are constantly changing their polarity—*i.e.* the North pole where the current enters the next instant becomes the South pole where the current leaves—yet, as this occurs many times in one second, the effect produced is the same as if the current was in one uniform direction. The lamp has no time to get cool; it does not go out before the oppositely-directed current passes through it and produces the same effect as the previous one. No flickering is observable. The impression produced by the glowing carbon on the human eye is retained by the retina for a far longer period than the duration of one surge of electricity through the lamp, and is not gone before the effect produced by the succeeding opposite wave makes its impression on our nerves. The Jablochkoff lamps used lately on the Thames Embankment are meant for this system of electric lighting with alternating currents.

In a "continuous current" dynamo, which is necessary for some purposes such as electro-plating, where the effect desired could not be produced if the direction of the current was continually altering, the electric current is made to pass always one way round the external circuit. This result is got by using the ingenious device of a commutator, which automatically deflects the current so as always to send it in an unvarying direction through the plating-bath or the electric lamp, as the case may be.

This commutator consists simply of a split tube, which is attached to the revolving armature, and may be seen in any dynamo working on the continuous system. This tube revolves with the revolving armature, and it is divided by an insulating substance into two parts; each half is alternately on the left and right of the space between the poles of the magnet, and the "brushes" which collect the current from the armature—*i.e.* the bundles of copper wire spread out like a brush which form each end of the outer circuit—are fixed in position, and the revolving commutator attached to the armature brings alternately one of its half-tubes into contact with a brush. Thus the half of the commutator which receives the current changes at the same time that the direction of the current through the coils of the armature is reversed; in this way the current sent out to the brush which receives the electric current from the armature is always in the same direction.

CONTRIVANCES FOR THE CROSS-FERTILIZATION OF PLANTS.

By J. Pentland Smith, M.A., B.Sc., *Lecturer on Botany, &c., Horticultural College, Swanley.*

THE statement is often repeated that Nature abhors the union of nearly-related individuals to one another, and many evidences of such abhorrence are found both in the animal and vegetable kingdoms. In the latter they are perhaps more obvious, as many plants exhibit contrivances which almost effectually prevent such unions.

The organs which are concerned in the reproduction of the higher plants are the flowers. A typical flower is

made up of four whorls of organs, named respectively, from without inwards, the calyx, corolla, andrœcium, and gynœcium. The calyx (καλυξ, "a cup") is composed of parts called sepals; they form the outer protective covering to the rest of the flower. The corolla (*corolla*, a little crown) is the gaily-coloured portion which attracts insects, and whose component parts are termed petals. The andrœcium (ἀνηρ, "a man," and οἰκος, "a house") is the male portion of the structure, and is formed of club-shaped bodies, the stamens; and the female part of the establishment is the gynœcium (γυνη, "a woman," and οἰκος, "a house"), which is made up of green modified leaves, the carpels, that are often more or less united to one another. As the andrœcium and gynœcium are immediately concerned in the sexual reproduction of the plant, they are called the essential organs, while the calyx and corolla are termed the floral envelopes.

The accompanying diagram (Fig. I.) shows the plan of such a flower, which, because it is in possession of both male and female organs, is said to be hermaphrodite. This name is derived from Hermaphroditus, a son of Hermes and Aphrodite, whose body, as related by Ovid, was united to that of the nymph Salmacis. This arrangement would imply self-fertilization, were it not that certain contrivances are manifested for its prevention. In the majority of hermaphrodite flowers the stamens ripen before the carpels. The club-like heads of the stamens — the anther lobes or pollen sacs — are filled with pollen grains, which are generally yellow in colour. The pollen contains the male fertilizing element; hence the ripening of the stamens previously to the carpels is termed protandry (πρωτος, "first," and ἀνηρ, "a man"). The lower portion of the carpels contains the ovules, and so is called the ovary. In each ovule is seated an *ovum*, or egg, the female element, which, when united with a cell from the pollen grain, develops into a young plant. Protogyny (πρωτος, "first," and γυνη, "a woman"), is then the term employed to denote that the carpels come to maturity before the stamens. The common Pelargonium of our green-houses, often but erroneously called a geranium, affords an excellent example of protandry. The stamens are perfectly ripe, and the pollen is shed before the stigma (the upper part of the carpels on which the pollen grains rest when they send down their fertilization tubes to the ovules) is ready to receive them. Only after this process is past does it display its bright red rosette in the centre of the flower. The "wee, modest, crimson-tipped flower," the daisy, has its pollen sacs united together; the carpels shoot up in the centre of the zone so formed, and, in doing so, scatter the already mature pollen over the expanded stigmas of the neighbouring flowers. Then the forked stigma opens out and is ready to receive, in like manner, pollen grains. Instances of protandry are exceedingly numerous, as the student of this fascinating department of botany soon finds out for himself. Protogyny is less common. It is seen in the Plantago or Plantain (*Plantago media*) of our roadsides. The stigma opens, and the pollen from another flower falls on it before its own pollen is mature.

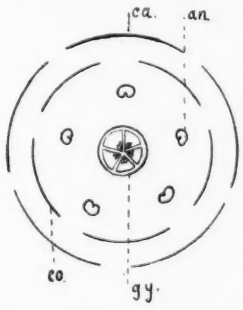


FIG. I.—Diagram or ground-plan showing typical arrangement of parts of a typical flower. *ca.*, calyx; *co.*, corolla; *an.*, andrœcium; *gy.*, gynœcium.

Insects are the active agents in cross-fertilizing these plants, and their aid is required in many other cases where the conditions are such that self-fertilization is impossible. They are attracted to the flowers by the gaily-coloured petals and stores of nectar. The latter is contained in nectaries so situated that in order to obtain it the insect must come into contact with the reproductive organs. The pollen with which its body is coated during its visit to one flower is brushed off on to the stigma of the next one of the same species on which it alights.

The contrivances exhibited by some hermaphrodite flowers to prevent self-fertilization are extremely complex, and in many instances quite amusing. The common Pansy (*Viola tricolor*) is a case in point. The stamens (Fig. II. 4, *st.*) have exceedingly short stalks, so that the anther lobes or pollen-sacs surround the ovarian, or ovule-

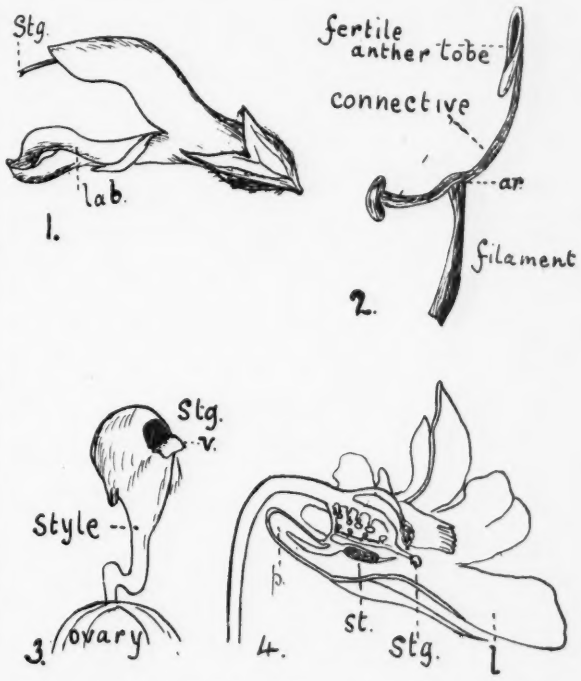


FIG. II.—1. Flower of *Salvia officinalis*; *stg.*, stigma. 2. Stamen of above. 3. Carpels of *Viola tricolor* (Pansy); *stg.*, stigma; *v.*, valve. 4. Flower of above; *l.*, lower petal forming labellum; *st.*, stamen; *stg.*, stigma; *p.*, pouch.

containing, portion of the united carpels. The stigma (Fig. II. 3 and 4, *stg.*), which is supported on a flexible stalk or style (*sty.*), stands right out from the pollen-sacs. Fertilization of any kind would thus be impossible without extraneous aid. The lower petal (*p.*) is pouched, and the entrance to the pouch is lined with long hairs. Into the pouch proceed two thread-like bodies, which are in each case developments of that part of the stalk of the stamens—the connective—which connects or binds the two anther lobes together. In this case they proceed from the two lower stamens. At the end of each of these filaments there are honey-glands that excrete honey into the pouch of the petal in which they are lodged.

The other portion of the petal (*l.*) forms a landing-place for insects which come in quest of honey. There are guiding lines on the corolla, which lead it to the entrance of the pouch. The hairs situated there prevent

it pushing in its proboscis too far. In the act of inserting its proboscis it depresses a valve (Fig. II. 3, *r.*) which previously closed up the orifice of the hollow stigma. Supposing it to have just returned from a visit to another Pansy, its head would be covered with pollen, which it would now deposit on the stigmatic orifice, where it would be retained by the sticky fluid secreted there. The pushing of the proboscis between the filaments forces apart the previously united pollen-sacs, and the pollen falls on its head. When it has sipped its fill of honey it retires, and, so doing, its proboscis closes the stigmatic orifice by uplifting the valve, thus effectually preventing self-fertilization.

The same process is repeated when next an insect visits a flower. Of course, were it to sip honey twice or thrice in succession from the same flower, self-fertilization would ensue; but, as a rule, an insect after one trial flies off to another flower.

Salvia, the Sage, which one meets so frequently in our woods, is no less interesting. Instead of having five stamens it has only two, and these are constructed in a peculiar manner. The typical stamen consists of a stalk or filament, and two pollen-sacs or anther-lobes, which are connected by a prolongation of the filamentous body that, as was previously mentioned, is termed the connective. The connective in Salvia is abnormally developed, so as to form a bent semi-circle (Fig. II. 2). There is only one fertile anther-lobe, which is borne by the upper portion of the connective. The filament of the stamen is not much elongated, and the whole connective is articulated to it (*ar.*). The two carpels are joined together; the style is so much elongated and bent that the bi-loped stigma on its summit (Fig. II. 1, *stg.*) protrudes beyond the corolla. The lower petal, like that of the Pansy, forms a landing-stage (*lab.*) for insects which seek honey secreted from nectaries at the base of the flower. When it pushes its proboscis into the corolla it comes in contact with the lower portion of the connective of each stamen, and in so doing it brings the upper portion bearing the pollen-sac on to its back, where pollen is deposited. On visiting another flower and endeavouring to obtain honey, its back rubs against the stigma and leaves the pollen there.

Fig. III.—Flower of *Aspidistra elatior* (natural size). *br.*, bracts; *r.*, stigma; *s.*, groove; *st.*, stamen; *p.*, pollen. (Copied by kind permission from *Transactions of Edinburgh Botanical Society*, vol. xix.)

Even such humble animals as slugs are sometimes instrumental in securing the cross-fertilization of certain flowers. Dr. Wilson, Keeper of the Herbarium in the Edinburgh Botanic Garden, cites, in the Journal of the Edinburgh Botanical Society, the case of *Aspidistra elatior*, which he considers to be fertilized through their agency. This plant is only found in this country in our greenhouses; it is used for decorative purposes. Its flowers scarcely rise above the ground, and are thick and fleshy; they are protected by a "series of papery bracts." The stigma (Fig. III., *stg.*) is exceedingly large and "roofs over the whole of the flower." The stamens (*st.*), which are eight in number, are found below the stigma. When the flower has just opened, the stigma is quite rigid. Its upper surface and the inner surface of the perianth* lobes are studded with crystals of lime that prevent slugs boring through their tissues. There is no aperture by which any animal can find entrance to the chamber beneath the stigma, and this organ at first is so firmly fixed to the perianth that an attempted separation causes breakage of the stigma itself. Suppose a slug to have entered the pollen-chamber of a flower of Aspidistra. In its peregrinations there its slimy body will become quite coated with pollen, which it will deposit on the stigma of the next one it visits during its wanderings on its surface in its endeavour to find an entrance to the pollen-chamber beneath. When fertilization has been thus effected, a remarkable change takes place in the stigma; it becomes "flaccid and free at its margin." Small apertures are thus left between it and the perianth lobes which admit the body of a slug into the chamber below.

There are no more common flowers in many parts of Britain than the Cowslip (*Primula veris*) and the Primrose (*Primula vulgaris*), yet it is doubtful if many people are acquainted with the method of fertilization prevalent in this form. To Darwin we are indebted for our knowledge on this head. Village children, as he remarked, are quite familiar with the two forms which the corolla of each of these flowers assumes; for when they endeavour to thread them into necklaces, they find their task easier in the one case than in the other. In both cases the upper part of

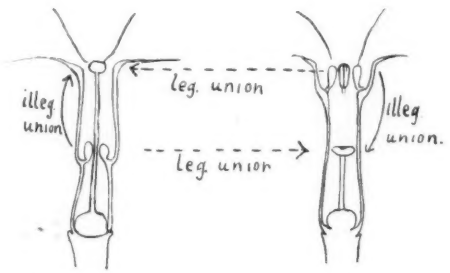


Fig. IV.—Diagram of two forms of *Primula*.

the corolla tube (Fig. IV. 1, 2) is wider than the lower portion, but in the former the wider part or *throat* extends much further down the tube than in the latter. The length of the style varies also, being so much more elongated in the first-mentioned case that the stigma is raised to the level of the orifice of the tube, hence the common name of this form, "pin-eyed"; whereas in the latter it only rises half-way up the tube. Besides, the pollen-sacs or anther-lobes of the short-styled form are situated at the upper part of the throat, so as to appear like the ends of a weaver's threads, which probably suggested their familiar name "thrum-eyed." They thus correspond in position with the stigma of the long-styled flower, and the anther-lobes of that form play a like part as regards the stigma of the short-styled form.

Both these are minor differences when compared with those we are about to mention. The long-styled stigma is round and comparatively rough on its upper surface; the short-styled one is smooth and depressed. The pollen-grains of the former are smaller than those of the latter. One type alone is borne by one plant, the other arises on a separate plant. The position of the anther-lobes in the short-styled flowers is such that the pollen-grains which fall from them could easily pollinate the stigma, were it not that they are so large that in nine cases out of ten they roll off. The slightly rough stigma of this type does not afford them a resting-place. The position of the

* When a calyx and corolla cannot be distinguished one from the other in the same flower, the floral envelope is called a perianth (περι, "around," ἀνθος, "a flower.")

anther-lobes in the short-styled flower prevents self-fertilization. The large pollen-grains developed there exactly suit the rough stigma of the long-styled form; they are retained by it whenever they fall there.

Such an examination of these two kinds of flowers would lead one to imagine that they are adapted for cross-fertilization, that it is intended that the pollen of the long-styled form shall fertilize the short-styled, and *vice versâ*. Darwin's experiments show that that this surmise is correct, for the greatest number of perfect seeds were obtained from such unions, so that Darwin termed these legitimate unions, all others illegitimate. Insects are the fertilizing agents here.

A flower of the same species of plant which exists under different forms is said to be heteromorphic (ἕτερος, 'other," and μορφη, "form"); when there are only two forms it is called dimorphic (δις and μορφη); when three, trimorphic, *ex.* the Lythrum. The dimorphism of the Primrose and Cowslip is always perfectly evident. There are no transitional forms between the types just noted.

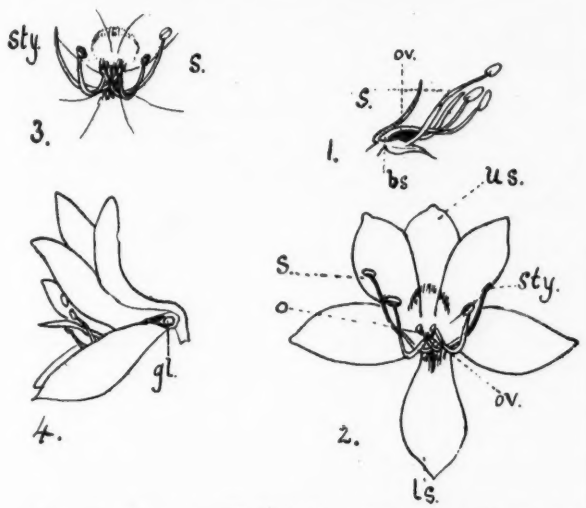


FIG. V.—Flower of *Wachendorfia paniculata*. 1. Side view of reproductive organs, natural size; *s.*, style; *ov.*, ovary; *bs.*, base of upper stamen. 2. Front view of a single flower (natural size). *us.*, upper outer segment of the perianth; *ls.*, lower inner segment; *sty.*, style; *s.*, stamen corresponding to the style, *o.*, aperture of passage to honey-gland. 3. Front view of the opposite type of the flower depicted in 2 (natural size). 4. Side view of a flower (natural size); *gl.*, honey-gland bearing a drop of nectar. (Copied by kind permission from *Transactions of the Edinburgh Botanical Society*, vol. xvii.)

Dr. Wilson, whose name we mentioned in connection with the fertilization of Aspidistra, has afforded us some very interesting facts in connection with that of another plant, *Wachendorfia paniculata*, which are especially interesting in this connection, inasmuch as the flowers of this plant are also dimorphic. The plant comes from Cape Colony. We cannot do better than quote his description of this plant:—"The inflorescence of this Wachendorfia (as exemplified by the plants experimented with) is a raceme of from seven to eleven scorpioid cymes,* each cyme bearing usually four or five flowers. Each flower lasts one day only, its duration depending on the amount of sunshine. On many days they may not be open more than six hours. . . . They are faintly scented. The perianth segments are much alike in size and shape. . . . As to the disposition of the perianth segments seen in front view, the uppermost outer segment (Fig. V. 2, *us.*) is vertical in position, and the other two horizontal. The upper inner segments stand at an angle of about 45°, and the lower one (*ls.*) is vertical. In profile the latter is seen to be capable of affording a lighting-place for insects. There are two honey-glands, situated in the angles between the bases of the upper outer segment and the adjacent inner segments. They open at the back of the flower by lenticular (or lens-shaped) apertures formed by the eversion (or turning outwards) of a small portion of the margin of the segments bounding the glands (Fig. V. *gl.*). The secreting portion is at the outer extremity of the glands. While quite exposed from behind, they are approachable from the front of the flower by two small orifices (Fig. V. 2, *o.*). Secretion, curiously enough, takes place the afternoon before the flower opens, and the glands remain conspicuously moist the day after flowering. The three stamens are inserted opposite the inner segments. . . . The two upper stamens diverge and curve outwards in a symmetrical manner, their bases being in the glandular region (Fig. V. 1, *bs.*), and their anthers both rising to the same height, above the level of the centre of the flower. The third stamen (Fig. V. 2, 3, *s.*) starts from the base of the lowest segment, passes under one of the other stamens, and curves upwards till its anther is a little higher than the other anthers. The style (Fig. V. 2, 3, *sty.*) passes beneath the other (opposite) stamen of the pair, and in position, length, thickness, and curvature corresponds with the odd stamen. . . . All the flowers of a particular inflorescence have the style bent to the same side. In the four plants which flowered, two had all the styles bent in one direction, and two all the styles bent in the opposite direction—the odd stamens, of course, changing sides. This arrangement constitutes the dimorphism of the species." The result of experiments made showed that by fertilizing the stigma of one form with the pollen derived from another, the larger number of seeds was obtained. "The presumption is that if an insect of sufficient spread of wings, after having visited a flower of one type, alights on a flower of the other, it must cross-fertilize the latter, inasmuch as the stigma will come exactly in contact with the part of the insect's wing bearing pollen from the former plant. And when one cross is being effected, new pollen is being acquired for pollination of the opposite type."*

* For explanation of these terms see KNOWLEDGE, Nov. 1890, in article on "Phyllotaxy, &c."

* *Transactions of the Edinburgh Botanical Society*, 1886–87. Dr. Wilson on Dimorphism of *Wachendorfia paniculata*.

Whist Column.

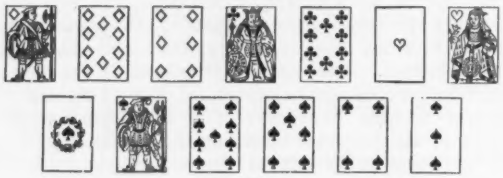
BY W. MONTAGU GATTIE, B.A.Oxon.

PLACING THE LEAD.

MANY of our readers have doubtless heard the story of the sarcasm uttered by the late James Clay, between the puffs of his pipe, when appealed to by a friend as to whether he (the friend) had not played correctly in passing, second in hand, a suit of which he held ace and king. "At the game of whist," was the reply, "as played in this country (puff, puff), no one is compelled to win a trick (puff) unless he likes." The unfortunate interrogator may well have felt crushed; but, nevertheless, the great player's aphorism, if taken seriously, contains a hint of much practical value. The following hand is

intended to illustrate the good policy in certain situations of passing a trick in order to place the lead advantageously. It will be seen that in this instance the player of the *coup* wins three tricks instead of one by his forbearance, and thereby exchanges defeat for victory.

HAND No. 18.



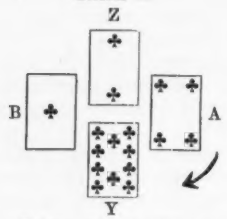
Y's Hand.

Score—AB, 4; YZ, 3.

Z turns up the king of diamonds.

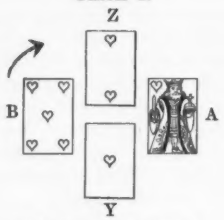
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



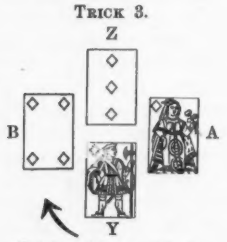
Tricks—AB, 1; YZ, 0.

TRICK 2.



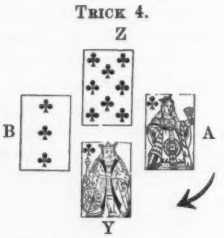
Tricks—AB, 1; YZ, 1.

TRICK 3.



Tricks—AB, 2; YZ, 1.

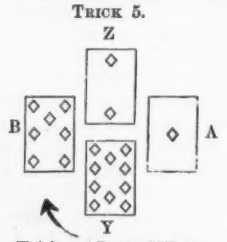
TRICK 4.



Tricks—AB, 2; YZ, 2.

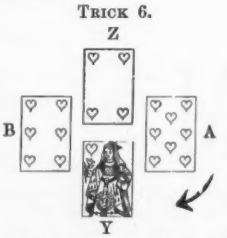
NOTE.—*Trick* 3.—Y has the command of both the adverse suits, and his partner has the king of trumps. His opponents are "four up," and his long suit of spades is very likely to be ruffed early. He therefore ventures on a trump lead. *Trick* 4.—The fall of the 3 of clubs indicates that A's original lead was from four only. Z can only have one more club (the 9).

TRICK 5.



Tricks—AB, 3; YZ, 2.

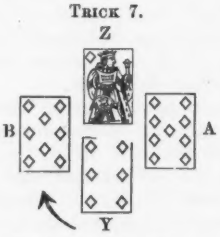
TRICK 6.



Tricks—AB, 3; YZ, 3

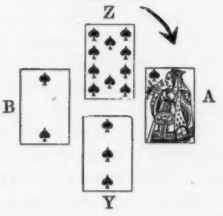
NOTES.—*Trick* 5.—Z has burnt his boats, and can do no better than continue the trumps. His daring is rewarded by Z's echo. *Trick* 6.—The 3 of hearts is marked in A's hand; B and Z each have two hearts remaining of uncertain value.

TRICK 7.



Tricks—AB, 3; YZ, 4.

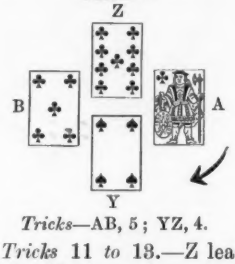
TRICK 8.



Tricks—AB, 4; YZ, 4.

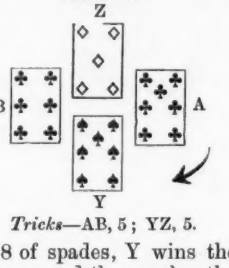
NOTES.—*Trick* 7.—Y now counts the hands as follows:—A has knave and another club, the 3 of hearts, and three spades; B has two hearts, and four dark cards, of which two must be clubs and another must be a spade; Z has the long trump, two hearts, and three dark cards, of which two must be spades. *Trick* 8.—The king of spades is marked in A's hand. Y sees, therefore, that if he wins this trick with his ace and returns the knave, A will win with the king and afterwards force Z in clubs; and, unless Z has a third spade, he will have to lead hearts up to B, and AB will not improbably make the odd trick and game. Accordingly Y passes the queen, knowing that Z has another spade to lead him after getting in with the trump. Even if B holds the two best hearts, and Z has a club, the *coup* affords a good chance of saving the game; for A will probably place the ace of spades with B, and, not knowing how the hearts lie, will in all likelihood continue the clubs after making his knave, in the expectation of an easy victory.

TRICK 9.



Tricks—AB, 5; YZ, 4.

TRICK 10.



Tricks—AB, 5; YZ, 5.

Tricks 11 *to* 13.—Z leads the 8 of spades, Y wins the trick with the 9, draws king with ace, and then makes the knave, and

YZ SCORE TWO BY CARDS AND WIN THE GAME.

A's Hand.	B's Hand.
D.—Ace, Qn, 9.	D.—8, 7, 4.
C.—Qn, Kn, 7, 4.	C.—Ace, 6, 5, 3.
H.—Kg, 8, 3.	H.—Kn, 9, 6, 5.
S.—Kg. Qn, 5.	S.—6, 2.
Y's Hand.	**Z's Hand.**
D.—Kn, 10, 6.	D.—Kg, 5, 3, 2.
C.—Kg, 10.	C.—9, 8, 2.
H.—Ace, Qn.	H.—10, 7, 4, 2.
S.—Ace, Kn, 9, 7, 4, 3.	S.—10, 8.

REMARKS.—*Trick* 3.—Under ordinary circumstances B's proper course would be to lead the ace and then the 7 of spades. Supposing him to do so in the present case, he would recover the lead with the king of clubs and lead another spade, which B would trump with the 7 (all spades but the king being marked in Y's hand), drawing the king of trumps. Y would then make a small trump on the clubs, and afterwards the queen of hearts; but the odd trick and the game could only be saved by very good play subsequently. *Trick* 6.—Y is clearly void of clubs, and A therefore prefers returning his partner's suit to forcing the weak trump hand. *Trick* 10.—A would have

saved the game by leading a heart, but he naturally places the ace of spades with his partner, and does not know that he might not be leading up to Z's major tenace in hearts. As already pointed out, the ensnarement of A was a not unimportant consideration in Y's scheme.

THE FACE OF THE SKY FOR FEBRUARY.

By HERBERT SADLER, F.R.A.S.

THE solar disc continues to exhibit signs of disturbance. Conveniently observable minima of Algol occur at 10h. 13m. P.M. on the 17th, and at 7h. 1m. P.M. on the 20th. Mercury may be observed as a morning star during the first two weeks of the month, but is not well situated for the amateur owing to the planet's considerable southern declination; while during the latter part of the month he is too near the sun for observation. He rises on the 1st at 6h. 19m. A.M., 1h. 22m. before sunrise, with a southern declination of 20° 50′ and an apparent diameter of $7\frac{1}{4}''$. Just one-half of the disc is then illuminated, and the planet is about equal to a small fourth magnitude star in brightness. He is at his greatest western elongation (25° 40′) on the morning of the 6th. On the 14th he rises at 6h. 25m. A.M., 0h. 54m. before sunrise, with an apparent diameter of 6·0″ and a southern declination of 20° 20′. Very nearly three-quarters of the disc is then illuminated, and the planet about equals a fifth magnitude star in brightness. After this he is too near to the sun to be conveniently observed. During the time over which our ephemeris extends he passes from Sagittarius into Capricornus, though without approaching any conspicuous star very closely.

Venus is a morning star, and but for her southern declination would be excellently placed for observation. She rises on the 1st at 4h. 37m. A.M., or 3h. 4m. before the sun, with a southern declination of 19° 18′, and an apparent diameter of 29″. About $\frac{43}{100}$ of her disc is then illuminated, and her brightness is about five-sixths of what it was on January 8th. On the 28th she rises at 4h. 48m. A.M., or 2h. 2m. before sunrise, with a southern declination of 19° 12′, and an apparent diameter of 21″. Nearly $\frac{52}{100}$ of her disc is then illuminated, and her brightness is somewhat less than four-sixths of what it was on January 8th. She is at her greatest western elongation ($46\frac{3}{4}°$) on the evening of the 13th. During the month she is in the constellation Sagittarius; but while she is above the horizon before sunrise, Venus does not approach any conspicuous star very closely. At about the time of sunrise on the 8th a $7\frac{1}{2}$ magnitude star will be seen some 60″ south of her southern limb, and at the same time on the 12th another $7\frac{1}{2}$ magnitude star will be seen about 70″ south of the planet's southern limb. Mars is, for the observer's purposes, invisible; and Jupiter is in conjunction with the sun on the 13th.

Saturn is an evening star, rising on the 1st at 7h. 43m. P.M., with a northern declination of 7° 27′ and an apparent equatorial diameter of 19·1″ (the major axis of the ring being 44·1″ and the minor axis 2·2″), On the 28th he rises at 5h. 44m. P.M., with a northern declination of 8° 16′ and an apparent equatorial diameter of 19·5″ (the major axis of the ring being 44·8″ and the minor axis 3·0″). Iapetus is at his greatest western elongation, where he appears at his brightest, on the 5th. At $9\frac{1}{4}$h. P.M. on the 6th Titan skirts the northern limb of the planet. At $2\frac{3}{4}$h. A.M. on the 15th Titan will be some 2″ south of the planet, and at about 7h. P.M. on the 22nd he will be some 2″ north of Saturn. At about $2\frac{1}{4}$h. A.M. on 25th Iapetus will be 51″ south of Saturn. The planet describes a short retrograde path in Leo during the month. Uranus is now an evening star, as he rises on the 1st at 0h. 4m. A.M. with a southern declination of 11° 27′ and an apparent diameter of 3·7″. On the 28th he rises at 10h. 16m. P.M. with a southern declination of 11° 21′. He is almost stationary in Virgo during the month in a region barren of naked-eye stars. Neptune is an evening star, rising on the 1st at 11h. 29m. A.M. with an apparent diameter of $2\frac{1}{2}''$, and a northern declination of 19° 22′. On the 28th he rises at 9h. 43m. A.M., with a northern declination of 19° 24′. He is practically stationary in Taurus, a little to the S.S.E. of ω Tauri, during the month, and is in quadrature with the sun on the 22nd.

There are no well-marked showers of shooting stars in February.

The moon enters her last quarter at 4h. 42m. A.M. on the 2nd; is new at 2h. 12m. A.M. on the 9th; enters her first quarter at 6h. 30m. P.M. on the 15th, and is full at 7h. 18m. P.M. on the 23rd. She is in perigee at 1h. P.M. on the 9th (distance from the earth 221,835 miles), and in apogee at 6h. P.M. on the 23rd (distance from the earth 252,700 miles). The greatest eastern libration is at 2h. 12m. P.M. on the 3rd, and the greatest western at 7h. 30m. A.M. on the 15th. In this and following numbers of KNOWLEDGE the occultations of stars and planets will be reckoned from the true north, in the direction N.E.S.W., as in double star measures.

The 7th magnitude star 96 Virginis will disappear at 6h. 56m. A.M. on the 1st at an angle of 99°, and reappear (in broad daylight) at 8h. 8m. A.M. at an angle of 319°. The $5\frac{1}{2}$ magnitude star μ Libræ will disappear at 1h. 59m. A.M. on the 2nd at an angle of 105°, and reappear at 3h. 5m. A.M. at an angle of 315°. This is a beautiful double star, the components being of $5\frac{1}{2}$ and $6\frac{1}{4}$ magnitude, 1·5″ apart, the pair being separable in a telescope of 3 inches aperture. On the 12th at 6h. 8m. P.M. the $6\frac{1}{2}$ magnitude star 29 Ceti will disappear at an angle of 84°, and reappear at 7h. 7m. P.M. at an angle of 215°; the 6th magnitude star 33 Ceti will disappear at 7h. 37m. P.M. at an angle of 71°, and reappear at 8h. 36m. P.M. at an angle of 234°; and the $6\frac{1}{2}$ magnitude star 35 Ceti will disappear at 8h. 42m. P.M. at an angle of 125°, and reappear at 9h. 10m. P.M. at an angle of 184°. At 7h. 2m. P.M. on the 17th the $5\frac{1}{2}$ magnitude star 121 Tauri will disappear at an angle of 47°, and reappear at 8h. 12m. P.M. at an angle of 290°. At 11h. 53m. P.M. on the 18th the 7th magnitude star B.A.C. 2154 will make a near approach to the lunar limb at an angle of 185°.

The following phenomena are for Washington mean-time (Washington is 5h. 8m. 12s. W. of Greenwich). Minima of Algol, February 10th, 11h. 27m.; 13th, 8h. 16m.; 17th, 5h. 5m. An occultation of an $8\frac{1}{2}$ magnitude star by Venus, February 18th, 16h. 0m.

OCCULTATIONS OF STARS BY THE MOON.

Star.	Magnitude.	Date. Disappearance.	Angle.	Date. Reappearance.	Angle.
		JAN.		JAN.	
κ Virginis ...	4·2	31d. 14h. 10m.	104°	31d. 15h. 21m.	327°
		FEB.		FEB.	
f. 89 Piscium	5·1	12d. 5h. 47m.	28°	12d. 6h. 50m.	265°
ω¹ Tauri ...	6·0	15d. below horiz.		15d. 13h. 38m.	215°
132 Tauri ...	5·3	17d. 8h. 4m.	62°	17d. 9h. 28m.	283°
ε Geminorum	3·2	18d. 7h. 57m.	92°	18d. 9h. 30m.	265°
κ Geminorum	3·6	19d. 12h. 27m.	65°	19d. 13h. 23m.	328°
B.A.C. 3206 ...	6·3	21d. 10h. 47m.	86°	21d. 12h. 6m.	325°
η Leonis ...	3·3	22d. 7h. 21m.	19°	22d. 7h. 26m.	10°
ν Virginis ...	4·0	24d. 12h. 59m.	85°	24d. 14h. 3m.	350°

XUM

Chess Column.

(CONDUCTED BY I. GUNSBERG.)

THE CHESS CHAMPIONSHIP.

By G. H. D. GOSSIP.

Great interest continues to be manifested in the match for the Championship of the World now in progress at the Manhattan Chess Club in New York; Mr. Steinitz, the Chess Champion of the World, having never yet been defeated in a match, and he has, moreover, by far the best Tournament record of any player living or dead. The closeness of the struggle, in which Mr. Gunsberg all but succeeded in making even games with his great opponent, has caused much excitement in American chess circles.

Subjoined is the score of the eighth game in the match:—

"GIUOCO PIANO."

WHITE (Gunsberg).	BLACK (Steinitz).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4 (*a*)	3. B to B4
4. P to Q3	4. Kt to KB3
5. P to QB3	5. P to Q3
6. B to K3	6. B×B (*b*)
7. P×B	7. Q to K2
8. Castles	8. Kt to Qsq
9. QKt to Q2	9. Kt to K3
10. P to Q4	10. Kt to Kt5
11. Q to Ksq	11. P to KB3
12. Kt to R4	12. Kt to R3
13. Kt to B5	13. Kt×Kt
14. P×Kt	14. Kt to Bsq
15. P to K4	15. Kt to Q2
16. Q to R4	16. Kt to Kt3
17. Q to R5 ch	17. K to Qsq
18. B to Kt3	18. B to Q2
19. QR to Ksq	19. P to B3
20. R to K3	20. K to B2 (*c*)
21. R to Kt3	21. QR to KBsq
22. P×P (*d*)	22. QP×P
23. Q to K2	23. P to Kt4
24. R to Q3	24. B to Bsq
25. R to Qsq	25. R to Qsq
26. Kt to Bsq	26. Kt to Q2
27. B to B2	27. Kt to B4
28. R×R	28. R×R
29. R×R	29. K×R
30. P to QKt4	30. Kt to Q2
31. B to Kt3	31. P to QR4
32. P to QR3	32. P×P
33. RP×P	33. Q to Q3
34. Kt to K3	34. P to QKt4
35. K to B2	35. K to B2
36. Q to Q sq	(Drawn game.)

Notes.

(*a*) The *Giuoco Piano* is Mr. Gunsberg's favourite opening, *dont il connait tous les détours.*

(*b*) Although this capture is recommended by the *Handbuch*, and by Mr. Steinitz, most leading experts prefer to retreat the Bishop to Kt 3rd.

(*c*) Thus liberating his Rooks!

(*d*) The advance of the QP is obviously out of the question, and the game already wears a drawish aspect, the position being blocked.

The twelfth game in the match.

"EVANS GAMBIT."

WHITE (Gunsberg).	BLACK (Steinitz).
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. P to QKt4	4. B×KtP
5. P to B3	5. B to R4
6. Castles	6. Q to B3
7. P to Q4	7. Kt to R3
8. B to KKt5	8. Q to Q3
9. P to Q5	9. Kt to Qsq
10. Q to R4	10. B to Kt3
11. Kt to R3	11. P to QB3
12. B to K2	12. B to B2
13. Kt to B4 (*a*)	13. Q to Bsq
14. P to Q6	14. B×P
15. Kt to Kt6	15. R to QKtsq
16. Q×RP (*b*)	16. Kt to Kt5 (*c*)
17. Kt to KR4	17. Kt to K3
18. B×Kt	18. Kt×B
19. Kt to B5	19. Kt to K3! (*d*)
20. KR to Qsq	20. B to B2
21. Kt to R8	21. R×Kt (*e*)
22. Q×R	22. K to Qsq
23. R×P ch	23. K×R
24. R to Qsq ch	24. Resigns (*f*)

Notes.

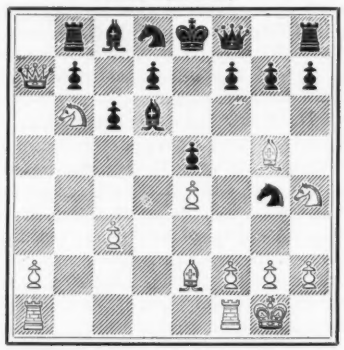
(*a*) The same moves occur in Game I. of the Tschigorin-Steinitz correspondence match. (*See* KNOWLEDGE for December 1, 1890, p. 282, where a diagram is given of this very interesting and difficult position.)

(*b*) Tschigorin also played this move in the above game.

(*c*) But here Steinitz deviates from the cable match in question, in which he played the other Knight to K3, which, to our thinking, is the best course.

Position after White's 17th Move.

BLACK (Steinitz).



WHITE (Gunsberg).

(*d*) If 19. P to Kt3; 20. Kt×B ch, Q×Kt; 21. QR to Qsq, Q to B2; 22. Kt×B, R×Kt!; 23. B×P ch, and White wins the exchange and the game.

(*e*) If 21. K to Qsq; 22. Kt×B, K×Kt; 23. Q to R5 ch, P to Kt3; 24. Q×KP ch, K to Kt2; 25. Kt to Q6 ch, with a very superior game, threatening P to QR4 or B×Kt and other miseries.

(*f*) If 24. B to Q3; 25. R×B ch, Q×R; 26. Kt×Q, K×Kt; 27. B×Kt, P×B, and White's superior *matériel* must win.

The score, at the conclusion of this game, stood—Steinitz 4, Gunsberg 3, drawn 5.

CHESS INTELLIGENCE.

Mr. Blackburne played 22 simultaneous games at Leamington on the 22nd December—a very successful performance.

In the City of London Chess Club Handicap, of no less than 148 competitors Messrs. Block, Loman, Smith, and Morian are the first four in the running up to date.

A triangular match is at present in progress at Pursell's, Cornhill, between Messrs. Tinley, Fenton, and Jusnagrodski. The former distinguished himself in the late Manchester Tourney by winning a prize, having previously gained a prize also in the Divan (Spring) Tourney last year.

Mr. G. J. Campbell, the well-known problem composer and leading English player thirty years ago, died suddenly last month from an attack of pleurisy, after an illness of only three days.

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